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SOFTWARE AND HARDWARE FOR SPEAKER DESIGN

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VERSION 05.007

22 May 1996

This file is available at the ftp site `ftp.graphics.cornell.edu` and is located in the directory `/pub/rahe/software`. The name of the file is `sahfsd**.doc`, where the `**` denotes a version number.

An earlier version of this file may still be available from the ftp site `ftp.uu.net` in the directory `/usenet/rec.audio.high-end/Software`.

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CHANGES SINCE VERSION 04

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- Updated info on Madisound.
- Updated info on CATT-Acoustic and CATT's email and Web addresses.
- Updated info on Audiosuite 2.0.
- Updated info on Canetics.
- Added info on Sonic Design Web page and email address.
- Added info on ABACUS.

CHANGES SINCE VERSION 03

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- Added mention of Radio Shack Sound Level Meter.
- Added mention of Rohde & Schwarz Audio Analyzer UPD.
- Added mention of ACO Pacific noise generator and ACO's Web address.
- Added mention of Audio Precision System Two.
- Added mention of Marton Music.
- Added mention of AkAbak software.
- Added mention of Thurlby Thandar TC200A LCR meter.
- Added mention of Analog Devices ADXL05 integrated accelerometer.
- Added mention of Sussex Technical Corp electronic crossovers.
- Added mention of Sussex Technical Corp bass equalizer.
- Added mention of LinearX's Web and ftp sites.
- Added mention of LECD software from Gendale Technology.
- Added mention of Liberty Aids Software from G.R. Koonce.
- Added mention of P500 test system from K & K International ApS.
- Added mention of Ashly Audio active crossovers.
- Added mention of the Speaker Building Web page.
- Added mention of Liberty Instruments' email address.
- Added mention of WinSpeakerz 95.
- Added mention of Filter Workshop.
- Added mention of Spectrum Analyzer 5.1 and Spectrogram 2.0.
- Added mention of Liberty Instruments' email address.
- Added mention of Microacoustics Web page.
- Added mention of Nexus PHI-3 Phase Test System.
- Added mention of pcRTAJr measurement system from LinearX.
- Added mention of HpW Works FFT Spectrum Analyzer.
- Added mention of SpeakerDes software.

- Added mention of DSA II measurement system.
- Updated info on Blaubox availability as freeware from Web address.
- Updated info on Audiomatica to include email address and Web page.
- Updated info on Acoustical Supply International.
- Updated info on new CLIO distributor in USA.
- Updated info on Pyle Pro Designer software.
- Updated info on Loudspeaker Design Cookbook, Fifth Edition.
- Updated info on Kirchner ATB measurement system.
- Updated info on TEF Products TEF20 audio analyzer.
- Updated info on Harris Technologies and their email address.
- Updated info on Marchand Electronics and their Web page.
- Updated info on Falcon Acoustics Ltd fax and telephone numbers.
- Updated info on A&S's name change to Just Speakers.
- Updated info on CALSOD 3.10 and CALSOD 1.40.

#### CHANGES SINCE VERSION 02

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- Added mention of Pyle Pro Designer 1.0 software.
- Added mention of Speakerphile speaker database software.
- Added mention of active crossover and equalizer units.
- Added mention of MathCAD utilities.
- Added mention of various active crossovers in new section.
- Added mention of AudioControl Industrial RTA and equalizer.
- Added mention of Liberty Audiosuite measurement system.
- Added mention of Welborne Labs active crossover kit.
- Added mention of Onsite Instruments anti-aliasing filters.
- Added mention of Larson Davis Laboratories real-time analyzers.
- Added mention of Analysis Advisor software.
- Added mention of TDR 4567 software.
- Added mention of PVDF transducers.
- Added mention of A1 Audio Test System.
- Added mention of Josephson Engineering microphones.
- Added mention of BestPlace software from RDL Acoustics.
- Added mention of Kemsonic AMS-PC measurement system.
- Added mention of Kirchner ATB measurement system.
- Added mention of DAAS 3L measurement system.
- Added mention of M31 microphone from LinearX Systems.
- Added mention of ProBox software.
- Added mention of RA Labs.
- Updated info on TEF Products TEF20 audio analyzer.
- Updated info on HyperSignal Acoustic software.
- Updated info on AModel software.
- Updated info on Sound System Design spreadsheet.
- Updated info on Microacoustic's telephone/fax number.
- Updated info on B&K address to include USA office.
- Updated info on Liberty Instruments' new fax number.
- Updated info on BassBox to cover new version 5.1.
- Updated info on CALSOD 1.30's documentation.
- Updated info on DRA Laboratories' address and telephone.
- Updated info on Neutrik's telephone and fax numbers.
- Updated info on Mahogany Sound's telephone and address.
- Updated info on Spectra Plus 3.0 software.
- Updated info on BoxModel to Version 4.0.

## CHANGES SINCE VERSION 01

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- Added address of CATT and description of CATT-Acoustic software.
- Added address of Lake DSP Pty Ltd.
- Added mention that Sound Lab is available for the Macintosh.
- Added entry [63] to list of references.
- Added info on pcRTA measurement system from LinearX.
- Added info on Fitduct.
- Added info on Blaubox.
- Added info on Woodsize.
- Added info on Panasonic microphone capsules.
- Added info on Loudspeaker Analysis and Design Program (LADP \_not\_ LEAP).
- Added info on Anechoic In-Room Response software for SoundBlaster.
- Added info on BK Precision LCR meters.
- Updated info on BoxModel 3.0.
- Updated address for C&S Audio Labs.
- Updated info on MLSSA and telephone numbers for DRA Labs.
- Updated info on Low Frequency Designer.
- Updated name of directory on ftp.uu.net where this file is archived.

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## INTRODUCTION

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The information presented in this document is divided into a number of sections:

- a. World Wide Web Sites for Speaker Design
- b. Commercial Loudspeaker System Design Software
- c. Shareware Loudspeaker Design Programs Available by FTP and BBS
- d. Commercial Acoustic Measurement Systems
- e. Transducers and Other Equipment for Loudspeaker Measurement
- f. Acoustic Modelling and Auralization
- g. Other Audio Design Programs
- h. Anything in Development
- i. Active Crossover Networks
- j. Useful References on Loudspeaker System Design
- k. Vendor Names and Addresses
- l. Acknowledgements
- m. How to Make New or Revised Submissions

There are many useful software and hardware tools available, but none are complete without a good knowledge of speaker design. Furthermore, you will NEED to supplement any paper design with hand tweaking for the best sound. Finally, no paper design is ever useful without good model parameters, and the parameters which manufacturers give you are often imperfect, so many good designers strongly recommend your own lab measurements. There is excellent advice on speaker measurement and speaker design in:

The Loudspeaker Design Cookbook, Fifth Edition

by Vance Dickason (C) 1995  
ISBN 1-882580-10-9  
US\$34.95 + US\$3.00 S&H (in USA) from Old Colony Sound Lab

You can also get a lot done with a simple spreadsheet or calculator and the equations in a book like The Loudspeaker Design Cookbook or some of the other useful references that are listed later. With that simple understanding, here is a list of the speaker design software available today, the dealers who sell that software, some shareware products which are available by FTP (PLEASE Register Your Shareware!), and some additional sources for a wide variety of speaker design tools.

Most of this list is the result of surveying marketing literature such as product brochures and advertisements. Some details have been included by actual users. However, do not assume that because something is listed here it is still available, has the exact features listed, or is bug free.

#### WORLD WIDE WEB SITES FOR SPEAKER DESIGN

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Apart from a variety of Web sites maintained by companies marketing their own audio products, there are also a number of Web sites springing up that contain information related to loudspeaker design that are maintained by audio enthusiasts. One very interesting site, known as The Speaker Building Page, is located at the following URL:

<http://web.hibo.no/~rpd/Speaker/>

As well as being a repository for a great deal of useful information and many novel features that are worth exploring in their own right, this site also contains a wealth of links to other audio-related Web sites. This makes it an excellent starting off point for further exploration.

#### COMMERCIAL LOUDSPEAKER SYSTEM DESIGN SOFTWARE

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Name: ABACUS 2.0  
Computer: Microsoft Windows 3.1  
Programmer: Vivek Mehta  
Price: US\$25 (private use)  
          US\$40 (commercial use)  
Download: <http://web.hibo.no/~rpd/Speaker/>  
          <http://www.ece.utexas.edu/~kelly/software/>  
          <http://www.csek.iprod.auc.dk/~odie/> (tentative)  
Description: ABACUS (A Box and Crossover User-friendly Simulation Software) is a simple Microsoft Windows-based program to help the DIY speaker builder to plot out the frequency response curves for vented cabinets. The responses of up to four user defined cabinets can be simultaneously seen, allowing easy what-if comparisons. The "Keele Alignment" for box volume and tuning frequency is calculated

automatically and its frequency response can be plotted. Another alignment called the "Mehta Alignment" is also offered as a starting point in the search for the ideal cabinet volume. The port calculator allows easy design of the port dimensions. The formulae used for calculating frequency response are those used in "Keele's Pocket Calculator" method. The crossover design section has not yet been implemented in version 2.0 of the software. All speaker driver parameters box volume and vent tuning combinations entered by the user are stored in a file for later reuse.

Name: Active Filter Designer  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: Fernando Garcia Ciesca, Marco A. Perez  
Price: US\$18  
Description: Designs active Butterworth filters in four configurations: highpass and lowpass in 2nd-order and 3rd-order.

Name: AkAbak  
Computer: Microsoft Windows 3.1  
Distributor: Panzer & Partner  
Programmer: Joerg W. Panzer  
Agent: Bang-Campbell Associates  
Price: US\$950  
Description: AkAbak simulates electroacoustical networks by a modular system. With the AkAbak script-driven input system, you can describe and document even complicated acoustical models. AkAbak comprises abstract filters and feedback units, electroacoustic drivers, as well as electrical and acoustic devices (eg. Duct, Enclosure, Horn, etc.). The simulation displays the impulse response of the sound pressure and power, directivity, as well as network potentials and flows. AkAbak solves the radiation problem by numerical integration of the radiation spheres of diaphragms and horns. This allows high-performance analysis, even in the upper frequency range. AkAbak's utilities include: synthesis of passive networks up to 30th order, including coil losses; design tool for highpass filtered vented boxes; parameter determination for dynamic and piezo drivers; data import/export. A full-function demo version and site licensing is available.

Name: AudioCAD  
Computer: Apple Macintosh  
Distributor: Carvin  
Price: US\$95  
Description: Vented and closed box design program based on the Thiele-Small model. It plots box response curves for different driver/box combinations and features overlay capabilities,

a large driver library, and calculation of vent and enclosure dimensions.

Name: BassBox 5.1  
Computer: Microsoft Windows 3.1 with 386SX or better CPU.  
Distributor: Harris Technologies, Old Colony Sound Lab, Audiosoft  
Price: US\$99  
Description: Low-frequency loudspeaker enclosure design program. Accepts both Thiele-Small ( $F_s$ ,  $Q_{ts}$ ,  $V_{as}$ ,  $N_o$ ) and electro-mechanical parameters ( $Q_{es}$ ,  $Q_{ms}$ ,  $C_{ms}$ ,  $M_{ms}$ ,  $R_{ms}$ ,  $B_L$ ), and can convert between the two types of parameters. Box design types: maximally flat vented box with  $Q_l$  adjustment, custom vented box, 4th and 6th order bandpass vented boxes (including one which ports rear chamber into front chamber), passive radiator box, optimum closed box, custom closed box, 3 multiple woofer boxes. Design options: small and large signal analysis, examine one speaker in several different boxes, examine several different speakers in the same box, manual override available for vented box tuning, multiple ports, box dimension calculator with 15 different volume shapes, enter speaker amplitude (acoustic response), use English or metric units, vent dimension calculator with various end correction options, save and recall designs. Graphs include: normalized sound pressure amplitude, sound pressure amplitude referenced to 2.83V, phase response, group delay, acoustic power, and impedance. Graphs can be saved in memory for later recall, and can be overlaid for printing. Includes test procedures to test and calculate speaker and passive radiator parameters (some basic test equipment is required to use this feature). A user-extensible driver database (now with over 1800 drivers) is included, and the program makes extensive use of on-line help.

Name: Bandpass BoxModel  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: Robert Bullock, Robert White  
Price: US\$50  
Description: Models bandpass loudspeaker systems with two chambers, one at the rear of the driver and one at the front. The program provides eight different acoustic arrangements. A number of loss variables can be specified:  $Q_{as}$  for losses due to enclosure filling;  $Q_{ls}$  for losses due to enclosure leakage; and  $Q_{ps}$  for vent or passive radiator losses. Up to four designs can be stored and displayed by the program. Graphical output includes: SPL magnitude and phase response, impedance magnitude and phase, vent air speed, and driver excursion. Both passive and active networks can be specified for use with bandpass designs.

Name: BENSON.EXE  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab

Programmer: G.R. Koonce  
Price: US\$10  
Description: BENSON.EXE is a program developed to do plots based on the model presented by J. Ernest Benson in his book "The Theory and Design of Loudspeaker Enclosures". This model includes leakage, absorption and port/passive radiator losses. You provide Thiele-Small parameters for one driver, and system data for up to three closed box, vented box, or passive radiator systems. Plots of small signal frequency response, include driver, port or passive radiator, and system output independently. These include phase shift for the above, and system group delay. The data can be printed in tabular form. Also included is a developmental version of SMALLPLT.EXE, which can be used to plot small signal frequency response, Zin magnitude and phase, and cone (and PR) displacement functions and maximum power input/output for the system.

Name: Blaubox 1.3  
Computer: MS-DOS  
Distributor: Blaupunkt  
Price: US\$199  
Fetch from: A 1992 edition of Blaubox can be obtained by pointing your Web browser to <http://users.aol.com/mulroy/blau2.exe>. This version has been released as freeware.  
Description: Designs woofer enclosures and crossovers, and is intended for use by dealers in aiding customers with enclosure design, including subwoofer and car applications. A database of Blaupunkt drivers is provided, and can be expanded with additional user-specified drivers. Closed-box, vented-box, and single- or double-ported bandpass enclosures are supported, including the isobarik configuration with all box types. Two box/driver combinations can be worked with simultaneously, allowing a pair of drivers to be compared. Small-signal sound pressure response plots are available, and enclosure designs include drawings showing how to cut material for three different box shapes. First- to third-order lowpass and highpass crossover designs are supported, which limits the designs to two-way systems as bandpass filters for midrange drivers are not supported. Full online help is provided, as well as online technical information on basic acoustics, electronics, woofer selection, and enclosure design. Printed output is supported on Epson dot matrix printers and Hewlett-Packard laser printers, and other compatible printers.

Name: BoxCalc  
Computer: MS-DOS  
Distributor: ARIBA  
Price: US\$99  
Description: Enclosure design of closed and ported systems, including a database of drivers.

Name: BoxModel 4.0  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: Robert Bullock, Robert White (both contactable by email)  
Price: US\$60  
Description: Features include: series and parallel, compound and isobaric enclosure designs; sealed, vented and passive radiator systems including large and small signal analysis; on-line help; optimized flat alignments; four concurrent designs; graphics printer screen plots supporting over 300 printers; over 1070 drivers in database file covering 4"-30" driver diameters and 53 manufacturers; equalized alignments through 8th order; filter assisted alignments; includes atmospheric conditions in design calculations; displays coefficients of transfer function; re-designed user interface compared with V3.0 and earlier; pull-down menu driven; includes box, port, and absorption losses in analysis; automatic file save/recall; DOS real mode operation; single and multiple port length calculations; auto detect CGA, EGA, and VGA display; runs on Intel 8088 through Pentium; no coprocessor required but recommended; box dimension calculator with fixed/custom ratios; separate graph traces for box, driver, equalizer, and loss contributions; toggle between Imperial and metric units; toggle max power graph based on resistance or impedance. Graphs include: maximum SPL, relative SPL, voice coil impedance magnitude and phase, acoustic phase response, group delay, transient response, driver piston excursion, vent airspeed, passive radiator excursion, maximum input power.

Name: BoxModel 1.0 for Windows  
Computer: Microsoft Windows  
Distributor: Old Colony Sound Lab  
Programmer: Robert Bullock, Robert White (both contactable by email)  
Price: US\$75  
Description: Assumed to include main features of the DOS edition, plus aperiodic loading.

Name: BoxPlot 2.0  
Computer: Microsoft Windows 3.x  
Distributor: Sparta Sound Company  
Programmer: Rick Carlson  
Price: US\$25  
Description: Designs closed and vented enclosures using Thiele-Small parameters. Includes filter assisted designs and vent calculator. Plots sound pressure response.

Name: BoxResponse  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: Robert Bullock, Robert White, Glenn Phillips  
Price: US\$50  
Description: Models closed, vented, passive radiator, and electronically

augmented vented boxes. Includes utility programs for computing air cored inductors, series notch filters, Zobel networks, L-pads, and vent design.

Name: CACD (Computer-Aided Crossover Design)  
Computer: MS-DOS  
Distributor: Scientific Design Software  
Price: US\$349 (?)  
Description: Design of crossover networks with optimization. CACD generates an equivalent impedance circuit so network designs use actual driver load. Allows up to 40 crossover elements and 20 nodes in the net list.

Name: CALSOD 3.10  
Computer: MS-DOS  
Distributor: Audiosoft  
Price: US\$320  
Agent: Harmonic Design GmbH, Sonic Design AB, Munro Associates  
ME Technologies, Marton Music  
Description: CALSOD 3.10 can model complete multiway (two-way, three-way, four-way, etc) loudspeaker systems. Features include: minimum-phase curve-fitting techniques enabling accurate simulations of driver sound pressure and impedance responses to be created, including phase response that is important in crossover network design; simulation of sound pressure and impedance response for vented, sealed, passive-radiator, filter-assisted and bandpass low-frequency alignments; the designer can specify the positions of drivers on the baffle for accurate simulation of effects on summed response caused by inter-driver time delays to the listening position; optimization of completely general user-defined passive and active crossover networks with up to 60 components; standard filter target functions for Linkwitz-Riley, Butterworth, Bessel, constant voltage and user-defined designs; curve-fitting optimizer for quickly creating sound pressure models of driver response; curve-fitting optimizer for creating impedance response models; curve-fit optimizer for estimating driver Thiele-Small parameters ( $Q_{es}$ ,  $Q_{ms}$ ,  $Q_{ts}$ ,  $F_s$ ,  $V_{as}$ ,  $B_l$ ,  $M_{ms}$ ,  $C_{ms}$ , etc) from experimental data using added-mass or box loading techniques; driver Thiele-Small parameters can also be estimated using a single measurement of the driver impedance when mounted in a vented-box of known volume and arbitrary tuning; driver impedance models use frequency dependent voice-coil inductance and resistance, parameters which can be automatically determined by the impedance curve-fit optimizer and Thiele-Small parameter estimator; automatic dcr calculation for air-cored inductors; piston approximation for driver models to simulate off-axis radiation characteristics; specify orientation of the principal radiation axis of each individual driver model used in the loudspeaker system; import measurement files from MLSSA, IMP, Audiosuite, CLIO, SYSid, System One, AIRR, PC Audio

Lab, AMS-PC, and LMS analyzers, with support for SPL optimization using up to 5 observation points to account for off-axis radiation characteristics; simulation of the step in the sound pressure response caused by diffraction of sound around the baffle; simulation of the effects of floor reflections on the sound pressure response by setting up a system of loudspeaker sources and images; simulation of room gain effects on low-frequency response; modelling of linear arrays. Plots include: impedance of each individual loudspeaker driver; input impedance of the crossover network and loudspeaker combination; voltage transfer function of each filter when it is loaded by its driver; filtered and unfiltered sound pressure response of each loudspeaker driver included in the system; desired target acoustic response function and target impedance function; summed sound pressure response of a multiway loudspeaker system, including the response at up to five different observation points; magnitude and phase response plots can be presented on a linear frequency scale to allow the linear-phase behaviour of the loudspeaker system to be easily assessed. The program comes with an extensive printed user's manual with detailed tutorial examples. Formulas are provided for determining initial crossover component values for Butterworth, Linkwitz-Riley, and Bessel filters.

Name: CALSOD 3.10 "Budget edition"  
Computer: MS-DOS  
Distributor: Audiosoft  
Price: US\$270  
Agent: Old Colony Sound Lab, Sonic Design AB,  
ME Technologies, Marton Music  
Description: The "budget edition" of CALSOD 3.10 has identical features and capabilities as the full-priced edition. However, the user's manual is supplied as a set of files on floppy disk, and it must be printed by the user before use. The files are provided in Windows Write 3.1 format, Word for Windows 2.0 format, and plain formatted ASCII text files.

Name: CALSOD 1.40  
Computer: MS-DOS  
Distributor: Audiosoft  
Price: US\$69  
Agent: Old Colony Sound Lab, Sonic Design AB, Marton Music,  
ME Technologies  
Description: CALSOD 1.40 is the low-cost edition of CALSOD 3.10, and therefore has somewhat fewer features. It does not include the active crossover design capability, nor the multiple observation point and impedance optimizers, nor the ability to directly import measurement files from audio test systems. It still provides a complete system modelling capability with the ability to predict the total summed response of a multiway system (but the simultaneous modelling of multiple off-axis response curves is not

available). The program is capable of modelling closed-box, vented-box, passive-radiator and closed rear chamber bandpass enclosures (both sound pressure and impedance, including phase response). A passive crossover network optimizer for multiway loudspeaker systems is also included. The extensive 240-page user's manual is supplied as a set of files on floppy disk, and it must be printed by the user before use. The files are provided in Windows Write 3.1 format, Word for Windows 2.0 format, and plain formatted ASCII text files. The user's manual includes detailed tutorial examples based on designing a two-way system, and describes the techniques for modelling woofer and tweeter response functions. Formulas are provided for determining initial crossover component values for Butterworth, Linkwitz-Riley, and Bessel filters, which are used as an initial starting point prior to running the crossover network optimizer.

Name: CASC (Computer-Aided Speaker Design)  
Computer: MS-DOS  
Distributor: Scientific Design Software  
Price: US\$199 (?)  
Description: Design of enclosures for closed-box, vented-box and passive-radiator systems. All systems can include a 2nd order circuit for design of filter assisted systems. Plots frequency response and displacement response curves.

Name: Crossover Design Plus  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: G.R. Koonce  
Price: US\$20  
Description: This program is intended primarily for the design of two-way and three-way passive crossovers. It also includes programs for evaluating the suitability of drivers for application in closed, vented, and passive-radiator enclosures (only a subset from the Driver Evaluation Plus package).

Name: Driver Evaluation Plus  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: G.R. Koonce  
Price: US\$20  
Description: This program evaluates the suitability of drivers for application in closed, vented, and passive-radiator enclosures. It designs vented boxes in detail, complete with port duct calculations. These programs, in general, will not handle closed-box, passive-radiator, large-signal, or equalized-enclosure design. The disk contains the original 1984 version of BoxResponse, but none of the recent upgrades are incorporated into it.

Name: FilterCAD 1.41

Computer: MS-DOS  
Distributor: Linear Technology Corporation  
Programmer: Richard F. Zarr  
Price: Free if used to design filters based on LTC components.  
Description: Facilitates the design of active filters of various orders and response shapes that are based on switched capacitor biquads from LTC.

Name: FilterCAD  
Computer: Microsoft Windows 3.1  
Distributor: LinearX Systems Inc  
Price: US\$695  
Description: FilterCAD is a program for the design and analysis of active filter circuits, and it produces component values as part of its analysis. When an analysis is completed, the program displays the circuits magnitude, phase and group delay response, as well as the schematic diagram of the circuit required to produce the network, including the component values. Many different circuit topologies are supported, and include first-order to eighth-order lowpass, highpass, bandpass, band reject, and multipass circuits. A demo is available by anonymous ftp, and there is also a Web site (see address details listed elsewhere).

Name: Filter Designer 1.5  
Computer: MS-DOS  
Distributor: SpeakEasy  
Price: US\$195  
Description: Passive and active filter design.

Name: FilterPro  
Computer: MS-DOS  
Distributor: Burr-Brown Corporation  
Price: Free  
Description: To aid in the design of active filters (Butterworth, Bessel, and Chebyshev), Burr-Brown provides a series of FilterPro computer-aided design programs (FILTER1, FILTER2, and FILTER42). These are available for downloading from the Burr-Brown BBS. Product literature describing the use of Burr-Brown components is also available (AB-017C, AB-035C, AB-017C, AB-034B, PDS-1070C).

Name: Filter Workshop  
Computer: Microsoft Windows 3.1  
Distributor: Old Colony Sound Lab, Synergetic Audio Concepts  
Author: Frank Ostrander  
Price: US\$80  
Description: Filter Workshop contains passive network design tools and is an instructional resource for network design. Passive network calculations include: design of attenuation networks (L-pads), highpass and lowpass filters, shelving networks (both highpass and lowpass), band-reject filters (parallel LCR conjugate networks), inductor winding calculations, and impedance correction networks (RC

conjugates). Component values are determined based on resistive termination. Standard filter functions include: 1st to 5th-order Bessel, Butterworth, Chebyshev (three types), Gaussian, and Linkwitz-Riley functions.

Name: Fitduct  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Price: US\$25  
Description: An aid to the designer of vented enclosures, Fitduct calculates vent dimensions using a more sophisticated algorithm than the simple equation that is normally applied. The user is required to provide two initial sets of length/tuning data, which are obtained by experimental measurements with the proposed enclosure, to which Fitduct applies a curve-fitting equation. Then, given the desired vent resonance frequency, the program will return the correct length of the vent.

Name: Loudspeaker Analysis and Design Program (LADP) for Windows  
Computer: Microsoft Windows 3.1  
Distributor: Old Colony Sound Lab  
Price: US\$135  
Description: LADP performs modelling, small signal analysis, and design of ported (standard or isobarik, and 6th-order active filtered), sealed (standard or isobarik, and 4th-order active filtered), passive radiator, bandpass, tubed, and horn-loaded enclosures. Bandpass enclosures (4th to 7th order) can be designed and effects of changing the front and/or rear volume can be examined. Large signal analysis is provided for ported (standard, series isobarik, or parallel isobarik), sealed enclosures. An active highpass filter (1st to 4th order) can be used to act as an infrasonic filter. Port dimension calculation for all designs and one to four ports is available. LADP can also design highpass and lowpass filters (1st to 4th order), including Bessel, Butterworth, Linkwitz-Riley, Chebyshev, and Legendre-Papoulis. Bandpass filters of order one or two can be constructed for all above types except Bessel. Up to three filter responses at a time can be displayed, including the phase angle. Polar plots of loudspeaker response are available in the +/- 90 degree range. Some basic architectural acoustics analysis can be undertaken, including room reverberation, impulse response, and room modal distribution. On-line help is provided to supplement information for each dialog box. It also contains helpful hints for designing, building, and testing enclosures and crossovers, as well as general car stereo information.

Name: LEAP 4.56 (Loudspeaker Enclosure Analysis Program)  
Computer: MS-DOS  
Distributor: LinearX Systems Inc  
Programmer: Chris Strahm  
Price: US\$249-US\$895

Description: LEAP contains a wide assortment of capabilities that pertain to transducer design, enclosure design, passive network design, active filter design, as well as complete system design. Importing and exporting of data is supported in a variety of formats. Graphs include SPL on-axis response, SPL power response, transducer impedance, network input impedance, port air velocities, transducer excursion, and filter transfer functions. Modelling of sealed or vented highpass and bandpass enclosures, including mutual coupling between multiple ports and drivers, as well as non-linear port effects is supported. Includes a built-in utility for speaker parameter determination from impedance measurements, and parameter correlation check. Driver voice-coil impedance models include frequency dependent resistive and reactive components. An extensive driver library is provided, which can also be updated and expanded by the user. LEAP data can be exported to other loudspeaker CAD programs such as CALSOD. A demo is available by

anonymous

ftp, and there is also a Web site (see address details listed elsewhere).

Name: Loudspeaker Enclosure and Crossover Design V3.6 (LECD)

Computer: MS-DOS

Distributor: Old Colony Sound Lab

Programmer: Gendale Technology

Price: US\$80

Description: LECD shows the SPL of two-way or three-way speaker systems against frequency, based on parameters entered and enclosures chosen. Sealed, vented, sealed-vented and vented-vented enclosures are catered for. Passive crossover network components for 1st through 4th order Bessel, Butterworth, Chebyshev, Gaussian, Linkwitz-Riley, and Legendre filters are calculated. The effect of speaker polarity and speaker offset can be modelled. Available graphs include: SPL/frequency response of each speaker in its enclosure; peak cone excursion of each speaker; on-axis SPL of complete system in magnitude, phase, phase delay or group delay; transfer function of each crossover filter section (woofer, midrange, tweeter) in magnitude and phase; input impedance magnitude and phase of each speaker and the complete system; equivalent squarewave response of the crossover filters and loudspeakers. A 109-page 190x229mm manual is provided.

Name: LMP "Souped Up" Edition (Loudspeaker Modelling Program)

Computer: MS-DOS and Apple Macintosh

Distributor: Sitting Duck Software & Old Colony Sound Lab

Programmer: Ralph Gonzalez, Bill Fitzpatrick

Price: US\$50 (MS-DOS), US\$40 (Apple Macintosh)

Description: LMP is a speaker system modelling program and crossover network design utility. It is designed to model multi-way systems, with the resulting frequency and phase response

curves predicting the on-axis sound pressure level produced by the interaction of your choice of crossover, drivers, and enclosure design. The Macintosh version adds visual and audible square-wave prediction using the internal speaker or audio output jack.

Name: Loudspeaker 6.0  
Computer: MS-DOS  
Distributor: Maximum Effort Software  
Price: US\$65  
Description: Box design for many different enclosures plus crossover network design.

Name: Loudspeaker Design Powersheet  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: Marc Bacon  
Price: US\$50 (Basic version)  
US\$70 (Professional version)  
Description: A spreadsheet program for computer-aided speaker design (requires a spreadsheet such as Lotus 1-2-3, Microsoft Excel, or Borland Quattro Pro. The professional version covers: 19 different types of bass loading with graphing capabilities; volume calculation for 5 different enclosure shapes; evaluation of cavity resonances, rectangular panel resonances, and the coincidence effect; 24 different types of crossovers, 10 miscellaneous programs for shaping circuits, Zobels, room interaction, and coil design; 8 programs for evaluating driver parameters and losses; electrical laws; conversion factors; room acoustics. A Basic version which includes 41 of the above programs is also available. Individual programs are accessed through a menu tree, and context sensitive help and an introductory README.1ST file are also included.

Name: Low Frequency Designer 3.0  
Computer: MS-DOS  
Distributor: SpeakEasy  
Programmer: Michael Chamness  
Price: US\$195  
Description: Low-frequency loudspeaker modelling of closed-box, vented-box, bandpass, and isobarik enclosures. Available plots include sound pressure and driver displacement, both of which can be viewed at the simultaneously. Curve families can be defined that allow you to study the effect of varying a single system parameter. Printing capability is included, mouse operation and writing of data files is supported, and full online help is available. The program works internally in 1/6-octave intervals over the 2Hz-2kHz frequency range, and allows you to set a plot frequency range within this interval. A curve fit mode is available, which varies parameters to try and fit the system response to a desired response curve.

Name: MacSpeakerz 3.0  
Computer: Apple Macintosh  
Distributor: True Image Audio  
Price: US\$299  
Description: Built in crossover and box calculators. Computes and displays frequency response, cone excursion, impedance, phase and group delay. Enclosures supported: closed, vented, 3rd-order closed, 4th-order bandpass, 5th-order bandpass, 6th-order bandpass, and isobarik variations. Includes the following calculators: tweeter attenuator; inductance compensation; resonance compensation; rectangular and trapezoidal box. Includes large driver library that can be expanded by the user.

Name: MacSpeakerBox  
Computer: Apple Macintosh  
Distributor: Old Colony Sound Lab  
Programmer: Eldon Sutphin  
Price: US\$40  
Description: Thiele-Small parameters are used to calculate the response for various design trade-offs in the low-frequency response of bass reflex, closed box (acoustic suspension), and infinite baffle types of enclosures.

Name: ModelONE  
Computer: MS-DOS  
Distributor: TDR (TransDimensional Research)  
Price: US\$288  
Description: ModelONE does the usual box simulations such as frequency response and cone excursion, but is really aimed at the car audio market. It includes a library of the typical radiation load patterns of over 150 different automobile interiors, all measured from the left front seat listening position with a B&K analyzer.

Name: NetCalc  
Computer: MS-DOS  
Distributor: ARIBA  
Price: US\$149  
Description: Crossover design, optimization, and system simulation. Includes an interactive and an automatic optimizer, as well as a graphical speaker editor and network editor.

Name: NETGEN  
Computer: MS-DOS  
Programmer: M. David Hayes  
Price: Freeware (a US\$10 donation will also be accepted)  
Description: This program is a 3-way loudspeaker crossover component calculator for first, second, and third order filter networks. It includes a network generator for creating a CIRCUIT module for use by CALSOD 1.30 or higher.

Name: Perfect Box 4.56  
Computer: MS-DOS

Programmer: Warren Merkel  
Price: US\$40  
Description: Simulates both closed-box and vented-box low-frequency systems, and includes port design capabilities. Can incorporate the effects of either a first or second order active equalizer. IBM, Epson or Hewlett-Packard LaserJet printers are supported. A data base of drivers is provided and can be extended by the user. Plots include amplitude and excursion, and up to four plots can be overlaid.

Name: ProBox 5.0  
Computer: Microsoft Windows 3.1  
Distributor: National Academy of Mobile Electronics  
Price: US\$100  
Description: Calculates configurations from sealed enclosures to triple-cavity iso-vent enclosures. Other features include: full color plots, view multiple box designs, view multiple response curves, IASCA wire calculator, breakdown of shapes and sizes in a cut sheet diagram, database to store box designs.

Name: Pro Designer 1.03  
Computer: MS-DOS  
Distributor: Pyle Industries  
Price: US\$199  
Description: Included in its design capabilities are models for 12 different subwoofer boxes (including bandpass). Models range from single chamber sealed to isobaric tri-chamber vented bandpass systems. Calculate and plot 4 different graphs simultaneously. Optimum sizes and tuning are automatically computed. Automatically generates mechanical drawings, 3-D views and bills of materials.

Name: PXO Passive Crossover CAD  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: Robert Bullock, Robert White  
Price: US\$50  
Description: Simple crossover design program for two- and three-way systems with graphics capability.

Name: Q&ETLD  
Computer: MS-DOS  
Distributor: Mahogany Sound  
Price: US\$9  
Description: Quick & Easy Transmission Line (Speaker) Design is a booklet that offers a step-by-step design procedure for transmission line speaker systems. Calculator style calculations are presented, and a computer disk for use with Lotus 123 is provided, as well as a 6.5" two-way TL project.

Name: QuickBox  
Computer: MS-DOS

Distributor: Sitting Duck Software & Old Colony Sound Lab  
Programmer: Bill Fitzpatrick  
Price: US\$35  
Description: Designs enclosures for non-equalized closed-box, vented-box, and one form of bandpass enclosure. Includes a library of speaker driver data which can be extended by the user.

Name: Room Design Powersheet  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: Marc Bacon  
Price: US\$60  
Description: Includes spreadsheet programs for dealing with room resonances, reverberation, boundary augmentation, wall diffuser design, and resonance traps. Context sensitive help and an introductory README.1ST file are also included.

Name: SNELL CARA and LEO  
Computer: MS-DOS  
Distributor: Snell Acoustics  
Programmer: Charles Nairn  
Price:  
Description: The Snell Computer Assisted Room Analyzer (CARA) enables the pitch and relative audibility of low frequency sonic colorations to be determined for any rectangular room. In addition, woofer locations for minimal excitation of these colorations can be determined using the Listening Environment Optimizer (LEO).

Name: SPEAK Acoustic Simulation Software  
Computer: MS-DOS  
Distributor: DLC Design  
Programmer: David Clark  
Price: US\$395 (single user), US\$995 (multi user)  
Description: Input parameter options: full driver specifications, front and rear enclosures, vents or passive radiators, passive crossover/equalizer, active filter order 1-5, parametric equalizers, driver non-linearities, multiway systems. Plotting options: pressure response, electrical Z V I, diaphragm displacement, off-axis response. Also simulates duct "organ pipe" resonances.

Name: SpeakerDes V1.21  
Computer: MS-DOS  
Programmer: Matt Gartner  
Price: US\$40  
Description: SpeakerDES includes: a CAD-like graphical interface that lets you easily change your loudspeaker's shape; closed and ported design models; a database of almost 500 readily available drivers (registered version); database search; real-time updating of the loudspeaker's frequency response and other parameters; passive crossover design, including graphical display and printing of schematics; an advisor feature; on-line help; design printouts with cutting

angles; save and load designs; convert between metric and imperial units.

Name: Speaker Designer 2.0  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: Stuart Bonney  
Price: US\$28  
Description: Loudspeaker system design aid and modelling tool for use with both closed and vented systems over the frequency range 10-300 Hz. The program computes and displays system frequency response, power handling capabilities, and relative sound pressure level outputs for each of 26 discrete frequencies over this range.

Name: Speakerphile 1.0  
Computer: Microsoft Windows 3.1  
Distributor: Acoustical Supply International  
Price: US\$395  
Description: Speakerphile is a database for use by loudspeaker designers. It includes a component database with information on woofers, tweeters, compression drivers, horns, passive crossovers, cabinet hardware, design software, and measurement equipment. Data on drivers includes electromechanical specifications, Thiele-Small parameters, cone and voice coil specifications, magnet data, mounting information, coverage patterns and design recommendations. A source database includes contact information for manufacturers, distributors, and sales representatives. Queries and searches can be carried out on any information in the database. A reference section contains acoustic, electronic, and speaker design formulas, as well as cabinet construction tips. Utilities provide unit conversions and other calculations useful in speaker design. File import/export facilities are included.

Name: Speaker System Designer 4.2  
Computer: MS-DOS & Microsoft Windows 3.1  
Distributor: ME Technologies, Old Colony Sound Lab  
Programmer: Bodzio Software  
Price: US\$110 to US\$210  
Description: The program enables the designer to create, then to evaluate, and finally to optimize 2 or 3 way loudspeaker systems. During the enclosure design phase, loudspeaker drivers may be interchanged for quick comparison. The effects of variations in driver parameters may be evaluated using parametric family plots. Driver compensation and crossover filter designs are supported. Room boundary reflections from three planes can be simulated. A crossover component optimizer works on individual driver/filter combinations with up to 12 variable components. The program accepts electromechanical parameters and the magnitude of the sound pressure response for individual drivers, which is entered at 100 discrete frequencies (separately selected

for woofer, midrange, and tweeter). Also includes: inductor calculator, L-pad calculator, round vent calculator, Zobel network calculator, series LRC calculator, and an impedance peak suppressor.

Name: SPICE  
Computer: Unix and PCs with DOS extenders  
Distributor: University of California at Berkeley  
Price: US\$250  
Description: Powerful general purpose circuit modelling program. Has transient, frequency response, noise and distortion analysis modes. Circuit can include passive components, transistors, diodes, and various types of sources. Various vendors have fixed bugs in SPICE, added features, and improved the product in their own ways, and have marketed their product with SPICE in the name. Some of the better ones are PSPICE by MicroSim and HSPICE by Meta-Software. The improved versions are much more expensive than the Berkeley product (US\$1,000 to US\$30,000).

Name: TERM-1  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Rockford Corporation  
Programmer: Wayne Harris  
Price: US\$199  
Description: Predicted response plots for sealed, ported, and isobarik sealed and ported enclosure designs. Port and enclosure layout design functions, including wedge, rectangular, or bandpass designs. Passive crossover design for 1st to 3rd order highpass, lowpass, bandpass filters based on Butterworth, Linkwitz-Riley, BEC, and Chebychev responses, and provision for notch filters. Acoustic curve overlays with crossover enabling toggle. High resolution graphics, menu-driven format, on-line help, and a database with a 10000-driver capacity. User's manual is over 220 pages in length.

Name: TERM-PRO  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Rockford Corporation  
Programmer: Wayne Harris  
Price: US\$399  
Description: Highpass, bandpass and lowpass crossover design for 1st to 3rd order filters, including Linkwitz-Riley, Bessel, BEC, Butterworth, and Chebychev. Graphical circuit diagram, predicted network response plots, dynamic cross-hair, common component substitutions, impedance compensation networks. Enclosure design for sealed, ported, single ported bandpass with and without coil, double ported bandpass with and without coil, including isobarik configurations. Provision for multiple drivers. Other features include: port and enclosure design and layout

functions (including wedge, rectangular, or bandpass designs), acoustic curve overlays, port design, toggle for English and metric units, and driver database management (database has capacity for 10000 drivers). Epson and HP LaserJet compatible printers are supported. User's manual is over 400 pages in length.

Name: TDR 4567  
Computer: MS-DOS  
Distributor: TDR (TransDimensional Research)  
Price: US\$120  
Description: Menu driven program for designing closed box, vented box, and a variety of bandpass configurations. It also helps to dimension a box and produces a cutting diagram. Multiple graphs can be overlaid for comparison of different enclosure alignments used with a given driver.

Name: Thunderbox  
Computer: MS-DOS  
Distributor: MTX  
Price: US\$199  
Description: Calculates box volumes, and tuning frequencies for vented, sealed, or vented and sealed rear chamber bandpass systems. Also handles single push/pull, or compound loading. Graphic data output includes frequency response and cone excursion from 10-200Hz. Up to four curves can be displayed at once. The user can simulate low frequency EQ for designing filter assisted alignments. The program comes with the entire line of MTX drivers loaded into its library, and additional drivers can be added to the database.

Name: TopBox  
Computer: MS-DOS and Apple Macintosh  
Distributor: ORCA Design and Manufacturing  
Programmer: Joe D'Apolito, Ron Warren, Ralph Gonzalez  
Price: US\$99  
Description: Design types include: 2nd, 3rd, and 4th order closed box; 4th, 5th, and 6th order vented box; 4th and 6th order bandpass; round and rectangular vents; metric or English units. TopBox allows the user to compare frequency response, maximum output SPL, power handling, and impedance. Overlay curves are supported. It is distributed with an extensible library of popular drivers and several sample designs.

Name: Transmission Line BoxModel  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: Robert Bullock, Robert White  
Price: US\$50  
Description: Models transmission line loudspeaker systems. The standard Thiele-Small model is used for the driver, and a modified Bradbury model is used for the acoustic section. Allows selection of driver parameters, line length and taper, and

properties of filling material, as well as choice of line air speed and filling porosity.

Name: Two Way Active Crossovers Plus  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: Gary Galo  
Price: US\$20  
Description: This program will perform the necessary calculations for eight common two-way active crossover designs. The schematics are drawn in text mode.

Name: WinSpeakerz 95  
Computer: Windows 95  
Distributor: True Image Audio  
Price: US\$299  
Description: Similar features to MacSpeakerz, letting you determine driver performance in various enclosure types. Calculators allow you to design passive crossovers, impedance compensation networks, and attenuators.

Name: Woodsize  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab  
Programmer: Allen D. Schultz  
Price: US\$35  
Description: This program determines lumber sizes for speaker cabinets. It was designed with auto sound in mind, and thus visualizes the cabinet as sitting under the rear deck of a typical sedan. Available cabinet types are: sealed, vented, single or double vented coupled cavity, and single or double vented coupled cavity isobarik. Input parameters are wood thickness, driver diameter and depth, air displaced by driver, first and second enclosure volumes, and first and second vent diameters and lengths. Output data are: the exterior dimensions of the cabinet; exact quantity and size of each wood piece required, including braces; exact square footage of wood required (no waste); internal depth, height, and width; and exact air displacement (cubic inches) by driver, vents, and bracing. The 13-page instruction manual includes assembly diagrams for cabinet options.

Name: WOOFER  
Computer: MS-DOS  
Distributor: Richard Plourde  
Programmer: Richard Plourde  
Price: US\$500  
Description: This program is used for designing enclosures, but also includes a method for incorporating room effects on response, and a utility that correlates motor design parameters. Graphic output includes power response, impedance, transfer function of network, cone pressure response and displacement, port pressure response and

displacement, port velocity, speaker power dissipation, efficiency, radiation load, impulse and step response, and two-way response, and two-way impedance. Room characteristics are specified using read, side, and floor distances, and floor reflection coefficients.

Name: XOPT 3.0  
Computer: MS-DOS  
Distributor: Peter L. Schuck Consulting  
Programmer: Peter Schuck  
Price: US\$199  
Description: Pop-up menu driven program with graphics for optimizing low, high, or bandpass crossover networks. Optimize frequency response of a speaker system with up to 5 drivers and 33 interconnected components on any axis or combinations of up to 5 axes. Requires user input of magnitudes of driver frequency response in dB and impedance in ohms at user specified frequencies. Calculates driver impedance phase from a model fit and frequency response phase using a Hilbert Transform. Uses relative locations of driver acoustic centres on the speaker front baffle for system crossover optimization.

Name: X-Over 2.0  
Computer: Microsoft Windows 3.1 with 386SX or better CPU.  
Distributor: Harris Technologies  
Price: US\$29  
Description: X-Over calculates the component values for 1st-order to 4th-order 2-way and 3-way crossover networks, load compensating networks, and L-pads.

#### SHAREWARE LOUDSPEAKER DESIGN PROGRAMS AVAILABLE BY FTP AND BBS

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There are numerous audio programs available for downloading from the Madisound Audio Projects BBS and their Web page (see the list of vendor names for Madisound's contact details).

The rec.audio.high-end (RAHE) archives are now at the following ftp site:

`ftp.graphics.cornell.edu`

and are stored in the directory `/pub/rahe`.

Look in the directory `/pub/rahe/software` to find many audio related software files. Some of the main files stored there are listed below. Note that the dates associated with each file in this list usually represent the date of the most recent file stored within each archive file, and will therefore usually not correspond to the operating system's time stamp on each file.

Many of the following files may also still be available from the ftp site `ftp.uu.net` in the directory `/usenet/rec.audio.high-end/Software`,

although that site has now been superceded.

FILE	SIZE	DATE	DESCRIPTION
<hr/>			
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abbs9403.uue	3,734	94-03-16	List of audio-oriented BBS facilities
acoustic.uue	20,029	88-04-25	Menu-driven acoustic worksheets (Lotus 123)
boundry .uue	58,002	90-01-11	Effects of room boundaries on speakers
boxdesin.uu	6,731	86-08-13	Box design worksheet (Lotus 123)
boxplt14.uue	79,483	91-09-08	Enclosure design program for Windows
d_cals3a.uue	177,087	95-06-05	Demo for CALSOD software
d_catta5.uue	756,305	94-07-01	Demo for CATT-Acoustic software
d_clio32.uue	936,574	95-06-05	Demo for CLIO measurement system
d_impm2 .uue	395,693	94-01-04	Demo for IMP/M measurement system
d_leap3 .uue	236,767	88-02-01	Demo for LEAP software
d_lfd2 .uue	189,098	91-07-17	Demo for Low Frequency Designer software
d_mlssa4.uue	347,758	89-09-21	Demo for MLSSA measurement system
d_sndlb2.uue	906,056	91-05-09	Demo for Sound Lab-PC measurement system
d_sysid4.uue	441,176	92-03-24	Demo for SYSid measurement system
d_syson1.uue	234,190	86-07-24	Demo for System One measurement system
dick_pierce.shar	137k	87-00-00	Dick Pierce's worksheet (Unix spreadsheet)
hpwfft1.zip	1058358	95-00-00	Demo for HpW Works PC-based FFT analyzer
listroom.zip	66,744	91-01-21	Compute speaker placement in listening room
loudsp .uu	73,039	88-11-26	Enclosure design program
loudsp30.uue	107,337	91-11-28	Enclosure design program (and BASIC source)
lsdpibm .uue	42,374	92-08-07	Enclosure design program (and C source)
netgen .uue	62,597	93-03-05	Loudspeaker crossover component
calculator			
newbox .uue	73,065	87-02-28	Vented box design program (and BASIC source)
perf .uu	303,355	90-03-13	PerfectBox enclosure design program
placemnt.uu	38,499	91-06-10	Room boundary augmentation worksheet
sdes121.zip	185,143	95-02-00	SpeakerDes enclosure design program
sdlmp215.zip	157,124	91-03-12	Loudspeaker and crossover modelling program
snell .uu	73,744	90-12-16	Room analysis and optimization program
speaker .uu	65,588	90-12-31	Vented and infinite baffle boxes (& BASIC)
speakers.uue	348,530	92-11-03	Thiele-Small parameter measurements
spkr48_3.6.shar	76,971	00-00-00	Speaker design library for HP48GX/SX

The files with the .uue extension have been encoded using the freeware Microsoft Windows program called Wincode 2.2, which can be found at the [ftp.cica.indiana.edu](ftp://ftp.cica.indiana.edu) ftp site or its mirror sites.

Submissions to the RAHE archives are welcomed, and can be placed in the the following directory:

/pub/incoming

Email notifying the maintainers of the RAHE site of these submissions can sent to the following email address:

rahe-moderator@graphics.cornell.edu

The RAHE 'charter' is really the 'Newsgroup Guidelines', and potential submissions should respect this. The guidelines are available for ftp from the directory /pub/rahe/guidelines.

#### COMMERCIAL ACOUSTIC MEASUREMENT SYSTEMS

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There are many different loudspeaker and acoustic measurement systems on the market today. They offer a wide range of features and capabilities, and many are particularly suited to production testing requirements. Because of the complexity of the task of loudspeaker system design, it is preferable to choose a test system that can measure both the magnitude and phase of the sound pressure response and impedance response. This will allow the greatest amount of flexibility. However, analyzers that measure only magnitude response may have other features that make them an attractive choice in many situations.

Name: A1 Audio Test System  
Distributor: Neutrik AG  
Price: US\$3940  
Description: Swept-sine measurements using a self-contained multi-function test generator with a 125mm by 70mm LCD graphic display. Includes low distortion generator and fully automatic distortion analyzer. Generator includes a sinewave and squarewave output 20Hz-20kHz with 0.2% resolution above 100 Hz. Six measurement functions are included: level, THD+noise, wow and flutter, noise, crosstalk, and relative level. Sweep functions selectable for 30 points or 200 points in 20Hz-20kHz range. Scope functions include auto-triggering, auto-scaling and auto-timebase setting. Interfaces include RS232 and parallel printer port (IBM PC compatible). Harmonic distortion display range 0.001% to 100%, with 0.0025% residual distortion.

Name: AIRR Anechoic In Room Response (software)  
Computer: MS-DOS  
Distributor: Old Colony Sound Lab, Julian J. Bunn  
Programmer: Julian J. Bunn  
Price: US\$50  
Description: Provides a loudspeaker measurement capability for owners of PCs equipped with a SoundBlaster or compatible sound card (such as the MediaVision Pro 16). Pulse mode excitation is used, followed by FFT analysis. AIRR features plotting of the digitized pulse received by the microphone and the frequency response of the loudspeaker system. Full on-line

help is provided. Measurement modes include: loudspeaker/amplifier response measurement; time/frequency averaging; square wave and  $\sin(x)/x$  pulse testing; and pulse on/off. For anechoic measurements, cut markers allow a window to be placed over the time data in order to remove the part caused by room reflections. Frequency response spectra can be stored as ASCII files on disk, which can then be read back by AIRR and subtracted from and/or overlaid on the current spectrum. Using the subtraction feature allows corrections to be applied for amplifier or microphone response. The AIRR display can be saved as a PCX file. The AIRR software includes operating instructions combined with on-line help.

Name: AMS-PC/ST Type 1656  
Computer: MS-DOS and Atari  
Distributor: Kemsonic Audio Measurement Systems GmbH  
Price: US\$800 (approximate)  
Description: The AMS-PC is an external audio measurement instrument that connects to the computer via the RS232 interface. It includes a sweep generator with voltmeter (and optional tracking filter). It can measure frequency response, impedance response, Thiele-Small parameters, and room acoustics. Options available: 1/3-octave tracking filter, phase measurement card, miscellaneous microphones, vibration transducer, input/output module, and software for quality checking.

Name: AM700  
Computer: Not applicable  
Distributor: Tektronix Inc  
Price:  
Description: The AM700 is a fully integrated test instrument with on-board capability, processing power, programmability, and rapid-access interface to meet the demands of applications ranging from audio product design through manufacture, installation, and service. The AM700 is self-contained and comes with analog and digital signal analyzers, analog and digital generators, internal CPUs, a monochrome VGA display, diskette drive, and memory. GPIB and RS-232 ports and a 3.5 inch diskette drive allow exchange of information and connection to modems, printers, and other output devices. As an audio analyzer the unit accepts balanced and unbalanced signal analog signals, as well as AES/EBU, SPDIF, and optical signals. Conventional measurement capabilities include FFT, graphical plotting, monitoring, and noise-level meters. The advanced test program for digital interface parameters includes jitter, eye diagram, data format, and time-domain measurements.

Name: A.R.M.S. (Acoustic Response Measuring System)  
Computer: MS-DOS  
Distributor: B.K. Electronics  
Price: US\$1000

500 Pounds Sterling

Description: The A.R.M.S. hardware is housed in a 19" case and comes with microphone and software. Measurement capabilities include driver Thiele-Small parameters, impedance curves and sound pressure response.

Name: Audio Analyzer Type 2012

Distributor: Brüel & Kjaer

Price: US\$7000 (?)

Description: Time selective response measurements. Includes FFT capability. Uses include: development and quality control testing of electro-acoustic and vibration transducers (loudspeakers, telephones, headphones, microphones, hearing aids, hydrophones, accelerometers); linear and non-linear system analysis; propagation path identification; acoustical measurements in rooms and vehicles. Features: three different measurement modes (time selective response, steady state response, FFT); up to 36 curves can be displayed simultaneously; frequency range 1Hz to 40kHz; distortion and noise <-80dB re full scale; automated measurement of individual harmonic, intermodulation, and difference frequency distortion components; 1600 line FFT spectrum; extensive post processing capabilities (+, -, \*, /, 1/x, x^2, sqrt(x), poles, zeros, windowing, editing, smoothing); preamplifier (microphone) and balanced or single ended direct inputs; on-screen help in English, French or German; input autoranging; MS-DOS compatible 1.44MB floppy disk drive for storage of data, setups, and auto sequences; IEE-488 and RS-232-C interfaces.

Name: Audio Analyzer UPD

Computer: Standalone unit

Distributor: Rohde & Schwarz

Price: US\$30000 (estimated)

Description: 24-bit measurement capability, with multiple inputs/outputs to handle the analog and digital world as well as mixed inputs. FFT block sizes between 256 and 8192 points can be selected in binary steps. A zoom FFT is available for increasing the frequency resolution. Includes a built-in PC with 3.5" floppy disk drive and color display.

Applications: development, quality assurance, production, service. Measurement functions: level or S/N; THD+N; harmonic distortion (including selected combinations of harmonics); modulation distortion; intermodulation distortion; wow and flutter; DC voltage; frequency and phase; polarity test. Test signals include: difference tones, sinewaves, two-tone signals, multi-tone signal comprising up to 17 sinewaves with any frequency and the same or different levels, sine burst with adjustable interval and on-time, squarewave, noise with a variety of probability distributions, arbitrary waveforms, FM signal for simulating impaired audio signals. Sweeps can be defined by means of a table or parameters such as start values, number of steps, linear/log stepping, or time

interval.

Name: AudioControl Industrial SA-3050A 1/3 octave RTA  
Computer: Standalone unit  
Distributor: AudioControl Electronic Engineering & Manufacturing Inc  
Audio Classics Ltd  
Price: US\$995 (SA-3050A with microphone)  
US\$1300 (SA-3050A with battery and printer interface)  
Description: The SA-3050A is a 1/3 octave real time analyzer with memories and SPL display. Features include: discrete ANSI class II filters; large, easy to read display selectable for RTA or SPL; digital full screen SPL or bar graph with peak hold; 3 display speeds; six non-volatile memories can be averaged and weighted; freeze frame; peak hold on RTA; built-in pink noise source; calibrated microphone; 92dB range plus fine sensitivity; 1, 2, 3, and 4dB resolution; optional A/C weighting filter; optional battery; optional printer interface; balanced XLR, balanced 1/4" and BNC connectors.

Name: Audiograph 3300  
Distributor: Neutrik AG  
Price: US\$3000  
Description: Swept-sine measurements. Includes low distortion generator and fully automatic distortion analyzer. A module is also available for measuring and recording phase response and group delay.

Name: CLIO 3.1  
Computer: MS-DOS  
Distributor: Audiomatica S.R.L.  
Agent: ORCA Design and Manufacturing Corp.  
W.A.R. Audio (Australia)  
Price: US\$1595  
Description: CLIO works as a precision 16-bit sigma-delta A/D and D/A audio analyzer, and is capable of generating any pre-defined stimuli such as sine, square wave, bursts, noise, and MLS (Maximum-Length Sequence). It is capable of measuring signals in both the time and frequency domains, and has a wide range of programmable output attenuations and input gains. The CLIO board is a half-length PC card that can be directly connected to a microphone or a separate (optional) battery powered preamplifier, which can perform A-weighting filtering or drive long cables. CLIO performs real measurements of acoustic phase, with the facility to zero the received signal's group delay. CLIO executes steady-state sinusoidal analysis with digital filtering of the input signal to achieve high noise immunity. CLIO is capable of measuring/performing: FFT of input signal with THD analyzer; THD with burst signals; electrical and acoustical phase; anechoic transfer function; MLS analysis of linear systems; system impulse response; energy time curve (ETC); cumulative spectra decay (waterfall plot); sinusoidal steady-state transfer

function; near-field response; impedance function; loudspeaker Thiele-Small parameters; real time 1/3 octave analysis; generation of predefined waveforms; time signal display (oscilloscope); measurement of inductance and capacitance values; amplitude measurements in SPL, dBV, dBm, and volts. The results of each measurement can be saved in a file and can be recalled for subsequent analysis. Overlaid plots are also available. Measurement files can be exported to loudspeaker CAD programs such as CALSOD and LEAP. Audiomatica has both an email address and a Web page (see their address details for full information).

Name: DAAS 3L  
Computer: MS-DOS  
Distributor: ADM Engineering  
Agent: Old Colony  
Price: US\$995  
Description: The DAAS 3L consists of a 16-bit card, associated software, calibrated microphone and documentation. Stimuli include: sine wave, tone burst, pink noise, MLS, white noise, periodic noise, and chirp. It uses a 16-bit A/D and D/A converter, with sampling rates of 48kHz and 6kHz, 16384 maximum sample length, and FFT lengths from 512 to 4096 points. Frequency range: 15-20000Hz high, 5-2000Hz low, maximum frequency resolution 0.5Hz. Measurement facilities include: frequency response, phase response, group delay, harmonic distortion, intermodulation distortion, TIM distortion, impedance response, Thiele-Small parameters, inductance and capacitance, oscilloscope function, energy time curves, smoothing, and waterfall spectrum plots.  
Input/output: 1x line out, 1x line in, 1x mic.

Name: DSA II - Digital System Analyzer II  
Computer: MS-DOS  
Distributor: ADM Engineering  
Agent: Old Colony  
Price: US\$7995  
Description: The big brother to DAAS3L, DSA II is made up of a converter PCB, associated software, front-end hardware in a rack mount chassis, and illustrated manual. Measurement functions and features: signal conditioning and measuring by 16-bit D/A and A/D converters; transfer function and impedance response; calculation of phase response with automatic correction of signal propagation time; group delay; step response and waterfall plots; distortion measurement as a function of frequency; distortion measurement with external signals; IM, TIM/DIM, and difference frequency distortion measurements; maximum frequency resolution 0.5Hz; export files for use in speaker CAD programs.

Name: ET1/ST1 motorized turntable  
Distributor: Outline snc  
Price: US\$1195 ET1 electronic control unit and ST1 turntable

US\$195 Optional ST2 turntable stand kit

**Description:** Motorized turntable capable of rotating speakers to a new angular position to facilitate measurements of off-axis response. Designed to work with analyzer's such as DRA Laboratories' MLSSA and LinearX's LMS.

Name: HpW Works FFT Spectrum Analyzer V1.0  
Computer: Microsoft Windows 3.1  
Programmer: Hanspeter Widmer  
Distributor: HpW  
**Description:** HpW Works FFT Spectrum Analyzer allows sampling from PC soundcards, harddisk recording PC boards, text files with various formats, wave files, external ADS hardware system (Burr Brown), or an internal test generator running on Window 3.1, 3.11, 95 and NT. The FFT engine is 64 bit complex and uses 1024 FFT points. It runs on a 90 MHz Pentium in 10 ms and the FFT size on the production version supports  $2^{20} = 1048576$  FFT points. The MDI interface allows multiple opened FFT windows and displays data such as labelling of harmonics, signal to noise ratio and total harmonic distortion, and noise floor. At least an 80386 CPU and 80387 coprocessor are required. The software is available in three versions: demo, light, and full. The demo is available from

Name: Hypersignal Acoustic (software)  
Computer: MS-DOS  
Distributor: SIGNALogic Inc  
Price: US\$1495  
**Description:** Powerful analysis software with features such real-time spectral analysis, 3-D spectrogram (waterfall) plots, dual trace display (dual channel), frequency zoom, room auralization in real-time, octave band analysis display (1/1-, 1/3-, 1/6-, 1/12-octave), macros, IIR filter construction, digital oscilloscope, FFT and inverse FFT analysis, convolution and correlation functions, and MLS stimulus/response capability. It can interface to the Ariel DSP16 board and the TEF Products TEF 20HI, as well as other boards including the Turtle Beach Systems Tahiti DSP/analog soundcard.

Name: IE-30A Real Time Audio Analyzer  
Computer: Hand-held instrument  
Distributor: Ivie Technologies  
Price:  
**Description:** The IE-30A is a hand-held real time analyzer and precision sound level meter. It measures amplifier gain, frequency response, output power, acoustic measurements, weighted or unweighted SPL measurements, peak accumulation, impulse measurement, and distortion analysis. It features: output connector for oscilloscope display, voice prints or strip chart recorder; alternate button for comparing memory data with real time display; precision low-noise preamp with A, C, or Flat weighted response characteristics; nonvolatile

memories will store or accumulate data; four digit LED readout with 0.1dB SLM resolution, calibrated in dB SPL and dBuV; digital hold; sound level meter provides fast, slow, impulse, and peak with true rms and peak detectors; selectable octave (25Hz to 20kHz in 10 ISO bands), 1/3-octave, or weighted 1/3-octave display modes (25Hz to 20kHz in thirty ISO bands); display has three decay times which allow for monitoring, peak readings or pink noise integration; thirty channel 480 LED display; display ranges of 15, 30, and 45dB are selectable with resolutions of 1, 2, or 3dB; air condenser microphone with 10Hz to 20kHz response; uses rechargeable batteries and can be operated continuously from AC adapter/charger; weight 1.2kg; dimensions (WxHxD) 203mm x 98mm x 54mm. Includes illustrated manual with instructions and a carrying case.

Name: IMP  
Computer: MS-DOS  
Distributor: Liberty Instruments Inc, Old Colony Sound Lab,  
ME Technologies, RCM-Akustik, Outline, Falcon Acoustics,  
Clear Sound  
Designer: Bill Waslo  
Price: US\$300 Unassembled basic IMP parts kit, including software  
US\$425 Unassembled basic IMP parts kit, including software  
plus unassembled Mitey Mike test microphone  
US\$440 Assembled basic IMP kit, including software  
Note that the above prices are approximate, and will vary  
from country to country (they are based on USA pricing).  
For home-brew builders, IMP software, firmware, enclosures,  
and blank circuit boards are available separately.  
Description: The IMP, along with an integrated amplifier and a computer,  
can serve as a network, spectrum, or impedance analyzer.  
The IMP interfaces with the computer via the parallel port.  
It is a transient capture system and software package which  
allows collection and analysis of 12-bit analog data up to  
4095 samples in length. Sample rates are selectable at  
either 61.441kHz or 1.92kHz which, along with the internal  
filtering, allows measurements from several hertz to 20kHz.  
The IMP records the speaker's time response to an  
approximate impulse and the software computes the  
corresponding frequency response function using the FFT.  
When measuring loudspeakers, near-field and semi-anechoic  
measurements can be merged to produce a composite response  
function that represents the anechoic response. A small  
electret microphone capsule is provided to facilitate sound  
pressure measurements. Impulse responses can be averaged to  
improve noise rejection. Sound pressure and impedance  
measurements are possible, and automatically include the  
true phase response of the system. Response plots include  
magnitude, phase, and waterfall. A driver's Thiele-Small  
parameters can be computed from impedance measurements.  
Full graphical user interface with mouse control and  
on-line help. Measurement files can be exported for use in  
loudspeaker CAD programs such as CALSOD and LEAP.

Name: IMP/M 2.0  
Computer: MS-DOS  
Distributor: Liberty Instruments Inc, Old Colony Sound Lab,  
ME Technologies, RCM-Akustik, Outline, Falcon Acoustics,  
Clear Sound, Marton Music  
Designer: Bill Waslo  
Price: US\$395 Unassembled IMP kit with MLS option, incl. software.  
US\$599 Assembled IMP kit with MLS option, incl. software.  
Note that the above prices are approximate, and will vary  
from country to country (they are based on USA pricing).  
For home-brew builders, IMP software, firmware, enclosures,  
and blank circuit boards are available separately.  
Description: The IMP/M adds the use of maximum-length sequences to the  
IMP's measurement capabilities, resulting in improved noise  
immunity. An MLS excitation signal also features a lower  
crest factor, which means there is less chance of clipping  
the output of the power amplifier or driving the speaker  
into nonlinear operation. The MLS stimulus greatly improves  
the repeatability of Thiele-Small parameter measurements,  
and all measurements are made much more quickly and  
conveniently, since background noise in the room is less of  
a concern. Very-low-frequency impedance measurements are  
also more reliable.

Name: Kirchner ATB 2.4  
Computer: MS-DOS  
Price: US\$2400 (approximate)  
Distributor: Kirchner Elektronik  
Description: The ATB is an 8-bit PC card with a 12-bit converter and a  
maximum sampling rate of 100kHz. Cutoff frequencies for  
measurements: 100kHz, 24kHz, 6kHz, 1.6kHz, 400Hz. The  
frequency response of the analog input is 0-60kHz. An  
8th-order antialiasing filter is included. Measurement  
facilities include: frequency response, impedance response,  
phase response, FFT analysis, loudspeaker radiation pattern,  
harmonic distortion, waterfall spectrum plots, Thiele-Small  
parameter determination, room reverberation time, and an  
oscilloscope function. Audio generator: sinewave,  
squarewave,  
with  
triangle, pulse, 1Hz-30kHz, THD < 0.01%. Noise generator  
1/3 octave or octave steps. Options: software for quality  
checking, input/output module, microphone, junction test  
box.

Name: Liberty Aids Software  
Computer: MS-DOS  
Price: US\$20  
Distributor: Old Colony Sound Lab  
Programmer: G.R. Koonce  
Description: These programs and files work with IMP and Audiosuite audio  
measurement systems. IMPSPACE designs anechoic test  
layouts. IMPROOM designs near field and far field test

layouts. IMPZOBEL designs simple and complex Zobels based on input .ZMA files. IMPPCOEQ (Passive Crossover and Equalizer) places a four-branch network ahead of the system defined by .FRD and .ZMA files. IMPEQLZR designs downslope equalizer functions used with .FRD files. Three datafiles are supplied for use with IMPSPACE.

Name: Liberty Audiosuite 2.0  
Computer: MS-DOS  
Distributor: Liberty Instruments Inc  
Agent: Old Colony Sound Lab, Marton Music  
Designer: Bill Waslo  
Price: US\$789 Software, calibrated mic, preamp, probes, and DSP ISA card.  
US\$100 Software upgrade from V1.0.  
Description: The Liberty Audiosuite is a component test system capable of measuring frequency/transient response, impedance, distortion, and spectral energy. Features include: dual channel MLS testing; cepstral analysis; gated sinewave testing for high dynamic range results at user chosen frequency points; steady state sinewave testing including measurement of harmonic distortion components as low as 0.03% with distortion versus frequency plotting; high purity multiprecision programmable signal generator; impedance measurements allow analysis of electronic components and automatic determination of loudspeaker Thiele-Small parameters; energy versus time displays for acoustical analysis of rooms and speakers; dual channel oscilloscope function with moveable markers; waterfall plots of cumulative spectral decay for resonance investigations; powerful data conversion facilities provide conversion between FFT-derived data (constant frequency increments) and log frequency format spacing or map data to user-defined frequency lists; programmable automatic operations for efficient research testing or cost effective production testing; choice of 13 sample rates up to from 5.5kHz to 48kHz with digital/analog anti-aliasing filtering; acquisition sizes of up to 16383 points; ASCII data export for compatibility with popular design and simulation packages; 2-channel 16-bit data acquisition with software controlled input/output gains; easy operation with on-line help; 1/1-octave to 1/12-octave band smoothing of measured frequency responses; pass/fail testing for production; RTA with A, B, C weighting and math; programmable script interpreter; frequency response math and editing; built-in Easy Scripts for simplified operation. The Liberty Audiosuite uses a versatile and powerful, yet inexpensive, DSP-based Personal Sound Architecture soundcard designed by Analog Devices and Echo Speech Corporation based around the ADSP2115 DSP processor. These boards include the Orchid SoundWave 32 and GameWave 32 Plus, the Cardinal Digital Sound Pro 16, the Wearnes Beethoven, the Paradise DSP16, and the Echo soundcard. These boards generally also provide standard compatible

multimedia sound and synthesis functions. A testing microphone needs to be purchased separately. The IMP microphone (plans available for builders) or the Mitey Mike could be used.

Name: LMS (Loudspeaker Measurement System)  
Computer: MS-DOS  
Distributor: LinearX Systems Inc  
Agent: ME Technologies, Munro Associates, and many others.  
Programmer: Chris Strahm  
Price: US\$1500  
Description: The LMS features a programmable sine wave oscillator, dual tracking filters with LP/HP/BP/BR modes, and a high-speed gating system for quasi-anechoic measurements. Includes a calibrated condenser microphone referenced to B&K microphone. Electrical and acoustical tests include: SPL response, gated SPL curves, rub/buzz test, impedance response, Nyquist plots, polar plots, and inverse FFT. System utilities are provided for scaling, smoothing, subtracting, dividing, and PASS/FAIL curve comparisons. The Hilbert Transform is used to calculate an approximation to the phase curve. A macro programming capability is included for automatic test operation. Measurement files can be exported for use in loudspeaker CAD programs such as CALSOD and LEAP. A demo is available by anonymous ftp, and there is also a Web site (see address details listed elsewhere).

Name: MLSSA 9.0  
Computer: MS-DOS  
Distributor: DRA Laboratories  
Agent: Harmonic Design GmbH, Munro Associates, and many others.  
Price: US\$3500 (hardware and software)  
US\$500 (MLSSA SPO Speaker Parameter Option)  
Description: MLSSA pioneered the maximum-length sequence (MLS) method of system analysis, which has significant benefits over simple impulse response measurement techniques. It has become a popular tool used by loudspeaker system designers and acousticians. It is an 8-bit PC card, with a 12-bit A/D converter is used, and the maximum sampling rate is 160kHz. Four sequence lengths are provided in hardware: 4K, 16K, 32K and 64K. MLSSA can measure a long impulse and store it to disk for later analysis. Measurements over a 1kHz bandwidth can be performed with 0.06Hz resolution, or 1Hz resolution over a 20kHz bandwidth. MLSSA can perform many mathematical operations on both time and frequency domain data files including average, add, subtract, multiply, divide, smoothing, convolution, correlation, and the inverse FFT. MLSSA also computes reverberation time and other acoustical parameters in IEC-standard octave bands, as well as energy-time curves (ETCs), absolute SPL and noise-criteria (NC) readings, speech transmission index (STI), ISO 3382 acoustical parameters, lateral energy fraction. MLSSA can act as an inductance and capacitance meter using impedance measurements (unaffected by the test

lead series resistance). MLSSA can compute the minimum-phase and excess phase response from measured frequency response data, including the excess group delay which makes it easier to check the minimum-phase behaviour of speakers. An Adaptive Window measurement technique is provided to mimic human hearing when performing room response measurements so that they look more like they sound. An integrated macro processor is provided, allowing complex sequences of commands to be recorded and played back. Measurement files can be exported for use in loudspeaker CAD programs such as CALSOD, LEAP, and XOPT. Frequency domain data can be exported and imported in linear format or logarithmic format for reduced file size. An additional software module (Speaker Parameter Option or SPO) allows measurement of Thiele-Small and electro-mechanical driver parameters using added-mass and closed-box methods. A rub detection measurement technique is also provided, and automated quality control acceptance limits and pass/fail functions are supported.

Name: Model 2800  
Computer: Not applicable  
Distributor: Larson Davis Laboratories  
Price:  
Description: The Model 2800 is a notebook size package that includes the following features: capability for precision sound level measurements; single-channel 1/1, 1/3 octave real-time analysis; single-channel FFT analysis to 800 lines; optional pink/white noise generator; room acoustics measurements, including RT60, transmission loss, STC, I<sub>a</sub> and NC; single-channel 1/3 octave statistical analysis; vehicle pass by noise measurements; three parallel A/D inputs for DC measurements (temperature, pressure, humidity, etc); battery power (rechargeable), option 3.5" floppy disk drive; option multi-window color display and mouse control instrument.

Name: Model 2900  
Computer: Not applicable  
Distributor: Larson Davis Laboratories  
Price:  
Description: Same as the Model 2800, but including these additional features: two channel 1/1, 1/3 octave real-time analysis; two-channel FFT analysis to 800 lines; two-channel 1/3 octave statistical analysis; optional sound intensity analysis (1/1, 1/3 octave and FFT); structural analysis (transfer function, coherence, etc); tachometer inputs for vehicle acceleration/deceleration and machinery runup/rundown tests; order tracking analysis with levels vs RPM/speed.

Name: PC-40 Real Time Audio Analyzer  
Computer: Hand-held instrument  
Distributor: Ivie Technologies

**Price:**

**Description:** The PC-40 is a hand-held computer controlled spectrum analysis system and precision sound level meter. General features include: programmable using BASIC; precision low-noise preamp (7Hz-35kHz, +/- 0.5dB 20Hz-20kHz) and laboratory quality air condenser microphone (10Hz to 20kHz); data and programs can be saved on optional disk drive; tilt up screen with selectable octave (25Hz to 20kHz in ten ISO bands), 1/3 octave (25Hz to 20kHz in thirty ISO bands), and weighted 1/3 octave displays (A, C, or Flat filters); can display two or more curves simultaneously; selectable detector response time; serial and parallel outputs; rechargeable battery operation for approximately 4.5 hours; 115VAC or 230VAC operation from 50Hz to 60Hz; drives digital XY plotter; optional plug-in cartridge printer, AC voltmeter, tape drive, modem or PROM burner. Sound level meter features: fast, slow, impulse, and peak response modes; instrument range 10dBA SPL to 149dBA SPL re 20uPa; four digit LCD readout with 0.1dB SLM resolution; digital display modes for continuous sample or display hold; selectable true rms or peak detectors. Display features: 240x64 pixel LCD display; display ranges of 16, 32 and 64dB with resolutions of 1, 2, or 3dB per step (0.25, 0.5, or 1dB per pixel); screen viewing angle is adjustable. Weight: 4.5kg. Dimensions: 337mm x 216mm x 83mm. Includes illustrated manual with instructions and a carrying case.

**Name:** PC Audio Lab 2.0 (software)

**Computer:** MS-DOS

**Distributor:** Microacoustics

**Price:** US\$300

**Description:** Software that enables the use of a 16-bit SoundBlaster or 16-bit Media Vision sound card to measure the performance of loudspeakers, electronics, and crossover filters. Features include: oscilloscope function, spectrum analyzer, network analyzer, impedance analyzer, distortion analyzer, loudspeaker analyzer, impulse analyzer, room acoustics analyzer, test cables, waterfall spectrum, detailed manual, graphical user interface.

**Name:** PC-Controlled Audio Frequency Analyser

**Computer:** MS-DOS

**Distributor:** Old Colony Sound Lab

**Programmer:** M. Ohsmann

**Price:** US\$52

**Description:** Software that works in conjunction with a PC soundcard to perform audio frequency measurements. The software allows you to measure the magnitude and phase response of a system as a function of frequency. The software also supports taking impedance measurements, as well as measurements of component values for resistors, capacitors, and inductors.

**Name:** pcRTA and pcRTAjr

Computer: Microsoft Windows 3.1  
Distributor: LinearX Systems Inc  
Price: pcRTA US\$1495 (including one microphone)  
pcRTAjr US\$695 (without microphone)  
Description: The pcRTA is an 8-bit full-length PC card that provides the functions of a real-time analyzer. Its features include: true RMS detection, pink and white noise generator, peak hold, curve storage, curve inverting, power response averaging, macro capabilities for quality control applications, and ASCII data import/export. It comes with a microphone capable of handling high SPL (clipping level at 156 dB). RT60, RT40, and RT20 measurements are supported. The pcRTA can analyze up to 4 microphones simultaneously. The software is a Microsoft Windows application and supports viewing of response curves in multiple colors. The pcRTA has applications to THX home theatre installation as well as IASCA and USCA scoring routines. The pcRTAjr includes most of the features of the pcRTA, but the bandpass filter complexity is reduced by the use of first-order bandpass filters instead of 2nd-order as in the pcRTA. The pcRTAjr also has only single microphone input, against the 4-microphone input capability of the pcRTA. Demos are available by anonymous ftp, and there is also a Web site (see address details listed elsewhere).

Name: Response 3 Production Test Analyzer  
Computer: Microsoft Windows software interface  
Distributor: Canetics  
Price: US\$11000 plus US\$1500 for each additional module  
Description: The Response 3 is designed specifically for production testing. It attains high speed by using a 32-bit floating point DSP. 16-bit sigma-delta stereo D/As are used to generate stepped sine, swept sine, pink noise, white noise, MLS, chirp, warble, tone pin and band limited noises. 16-bit sigma-delta stereo A/Ds provide over 90dB of usable signal to noise ratio. Microsoft Windows software interface provides color graphics output to screen and a variety of monochrome and color printers. Available tests include: absolute and differential frequency response, Thiele-Small parameter estimation, rub and buzz, and harmonic distortion. Graphs include frequency response, response with tolerances, impulse, pass/fail indication, and crossover network response. Full data logging facilities are provided for production line quality assurance tracking. Hardware options include modules for Thiele-Small parameter measurements, crossover testing, an integrated DC power amplifier, and microphone preamps/power supplies.

Name: Scantek Type 840 Real-Time Analyzer  
Computer:  
Distributor: Scantek  
Price:  
Description: The Type 840 is a real-time analyzer. It also implements a maximum length sequence (MLS) option for higher signal to

noise ratios under adverse conditions. The device can be used for acoustical measurements, including reverberation time and transmission loss.

Name: Spectra Plus 3.0 (software)  
Computer: Microsoft Windows 3.1  
Distributor: Pioneer Hill Software, MCM Electronics, ME Technologies  
Price: US\$395 software only  
US\$629 bundled with Turtle Beach Tahiti soundcard  
Description: Works with any Microsoft Windows compatible sound card, but results are dependent on soundcard quality. Features: dual channel FFT analyzer; narrowband and 1/3-octave analysis; distortion analysis; real-time mode that processes the audio signal and displays the frequency response curve; recording mode to store data as .WAV files for later playback; post-processing mode to analyze previously recorded data; time series, spectrum display, 3D waterfall spectra, spectrogram, and phase plots; maximum sampling rate is 44.1kHz; maximum FFT block size is 16384 points; signal generator utility can produce white or pink noise, high-speed sine wave sweeps (both logarithmic and linear chirps can be generated), discrete tones, sawtooth, pulse, and squarewaves; digital filtering; decimation and triggering; overlap processing; RT60 plots. Applications: acoustic research, distortion measurements, noise analysis, frequency response testing, vibration measurements, transfer function measurements. A Turtle Beach Tahiti card is recommended for best results. Pro quality soundcard specifications: DC-19kHz flat to 0.2dB, THD<0.005%, S/N -90dB, 2 channel, 16 bit, 44.1kHz sampling.

Name: Spectrogram 2.0  
Programmer: Phillip Van Baren  
Computer: MS-DOS, Linux, Sun SparcStation  
Web URL: <http://bul.eecs.umich.edu/~phillipv/signal/>  
Ftp: <ftp://oak.oakland.edu/SimTel/msdos/sound/specgrm2.zip>  
<ftp://bul.eecs.umich.edu/pub/linux/specgrm2.tar.gz>  
Price:  
Description: This program samples the input from a sound card, performs an FFT, and displays the output in the form of a spectrogram. INI file, command line, and run-time options are available to set the sampling rate, FFT size, display color scheme, and more. Under MS-DOS, 8-bit and 16-bit SoundBlaster compatible soundcards are supported, as are ProAudio Spectrum-16 cards, or any card which supports the VESA audio interface BIOS extensions.

Name: Spectrum Analyzer 5.1  
Programmer: Phillip Van Baren  
Computer: MS-DOS, Linux, Sun SparcStation  
Web URL: <http://bul.eecs.umich.edu/~phillipv/signal/>  
Ftp: <ftp://oak.oakland.edu/SimTel/msdos/sound/freq51.zip>  
<ftp://bul.eecs.umich.edu/pub/linux/freq51.tar.gz>  
Price:

**Description:** This program samples the input from a sound card, performs an FFT, and graphs the output. INI file, command line, and run-time options provide the user with the ability to select linear/log frequency and amplitude scales, as well as sampling rates, length of FFT, and windowing functions. Under MS-DOS, 8-bit and 16-bit SoundBlaster compatible soundcards are supported, as are ProAudio Spectrum-16 cards, or any card which supports the VESA audio interface BIOS extensions.

**Name:** SR770 and SR760 FFT Analyzers

**Computer:**

**Distributor:** Stanford Research Systems

**Price:** SR770 US\$6500

SR760 US\$4750

**Description:** Features of these FFT analyzers include: 90dB dynamic range; 476uHz to 100kHz frequency range (real-time bandwidth); low distortion source (SR770) with sine, two-tone, chirp, white and pink noise; source is internally synchronized to generate frequency response measurements accurate to 0.05dB; math functions; marker. Analysis functions include 1/3 octave, band, sideband, and THD, as well as data tables and GO/NO GO testing. Using the SR770's low distortion synthesized source, Bode plots of amplitude, phase, and group delay can be generated.

**Name:** SYSid and DSP16+ card

**Computer:** MS-DOS

**Distributor:** Ariel Corp, SYSid Labs

**Price:** US\$3000 (Hardware & Software)

**Description:** FFT-based transfer function analysis with impulse, chirp, sinusoidal, MLS, and user-defined stimulus signals. Features include: dual channel 16-bit analysis; full audio bandwidth up to 50kHz sample rate; high frequency resolution with up to 16384 point FFTs; RT60 measurements; 3D waterfall displays; electrical impedance measurements; anechoic speaker simulation; automated measurement and display of intermodulation and harmonic distortion; third-octave and octave band analysis; macros for automated operation; on-line help; save results to disk for future analysis or comparison. SYSid can display phase or group delay along with amplitude response. Measurement files can be exported for use in loudspeaker CAD programs such as CALSOD.

**Name:** System One

**Computer:** MS-DOS and Windows 3.1

**Distributor:** Audio Precision Inc

**Price:** US\$? (varies depending on options)

US\$1000 upgrade to APWIN software interface

**Description:** Stepped-sine measurements. Modules available for measuring phase response. Measurement files can be exported for use in loudspeaker CAD programs such as CALSOD and LEAP.

**Measurement capabilities:** frequency response; noise;

signal-to-noise ratio, crosstalk; gain; loss; absolute level; level with respect to any reference; total harmonic distortion; intermodulation distortion; phase; and wow and flutter. These tests can be performed in accordance with virtually all published standards (including those of SMPTE, DIN, CCIR, EIA, IHF, NAB). The System One comes standard with a DOS user interface, but the APWIN audio testing software is available as an option and runs under Windows 3.1.

Name: System One with DSP (System 202)  
Computer: MS-DOS  
Distributor: Audio Precision Inc  
Price: US\$11950 (varies depending on options)  
Description: FFT analyzer with MLS analysis capability.

Name: System Two  
Computer: Microsoft Windows 3.11 and Windows 95  
Distributor: Audio Precision Inc  
                  IRT Electronics Pty Ltd (Australia)  
Price:           SYS-2022 two-channel analog test set.  
                  SYS-2222 analog domain test set plus DSP modules.  
                  US\$18000 SYS-2322 dual domain test set plus digital I/O.  
                  SYS-2300 same as SYS-2322 but no analog domain capability.

Description: The System Two is designed for use from an external computer, including small notebook computers. It includes true Dual Domain architecture, allowing measurements in both the analog and digital domains. Analog hardware generator and analog hardware analyzer for analog domain devices is separate and independent from DSP modules which stimulate and analyze digital domain devices. Analog generator: distortion -120dB, flatness 0.01dB. Analog analyzer: residual noise -117.7dBu, flatness 0.01dB, residual THD+N -110dB (0.0003%), and FFT analysis following analog notch filter down to -140dB. Digital domain: signals are pure to -135dBFS, THD+N residuals below -120dB, and FFT dynamic range and accuracy extend to -140dBFS. System Two's user interface is the APWIN software (Windows 3.11 and Windows 95 versions), and includes extensive on-line help. APWIN features include: keystroke-learned test procedures, easy creation of acceptance limits, sweeping with automatically computed steps or from tables, and a data settling algorithm which maximizes sweep speeds while still providing stable, repeatable data. FFT analysis via synchronous multi-tone techniques operates with no time domain windowing function before the FFT, allowing for the first time proper noise measurements of compressors, processors, and noise gates. Signals generated in both analog and digital domains: sinewaves, squarewaves, SMPTE/DIN, CCIF, and DIM/TIM IMD signals. Additional analog-generated signals include: random and pseudorandom white and pink noise, bandpassed noise. Multitone signals are generated in the digital domain and available at both

digital and analog outputs. Predefined and user defined equalization curves can be applied to analog or digital generator outputs during a sweep, or a measured parameter may be equalized. Complete test setups and measurement results can be stored to disk for later retrieval.

Name: TEF System 20 and Sound Lab Software  
Computer: MS-DOS and Macintosh  
Distributor: TEF Products  
Price: US\$5000 (dependent on hardware and software configuration)  
Description: The TEF system is a computer-based analyzer designed to make quick, accurate measurements of room acoustics, sound systems, and audio components. TEF measurements are then used to help solve room acoustics problems, determine installation parameters for large sound systems, or determine the performance of individual system components. The term TEF is derived from "time, energy, frequency." TEF functions are based on Time Delay Spectrometry, a measurement method developed by the late Dr. Richard C. Heyser. Measurement capabilities include: 3-D waterfall plots; production testing; frequency response, phase response and group delay; polar response; frequency time curves; octave noise measurements; energy time curve (ETC); Nyquist display; SPL meter; oscilloscope; single channel FFT with up to 512k points; ALcons; RASTI; MLS measurements with 24kHz bandwidth, data sample lengths 255-512k points, alternate sequence seeds; display modes include overlay, difference, and % octave smoothing; file import and export facilities in a variety of formats. A seven-disk demo software set provides a comprehensive review of all seven modules of the Sound Lab software.

Name: Woofer Tester  
Computer: MS-DOS  
Distributor: C&S Audio Labs  
Price: US\$399  
Description: Automated Thiele-Small parameter measurement system, comprising a standalone unit that interfaces to a computer via an RS-232 port. For a raw driver or sealed box it measures Fs, Qts, and Vas. For a vented box it measures Fsb, h, and Alpha. It includes a digitally controlled oscillator and volt meter.

#### TRANSDUCERS AND OTHER EQUIPMENT FOR LOUDSPEAKER MEASUREMENT

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For additional hardware including high-impedance probes, a mic/probe preamp, Echo soundcard, and calibrated microphone, please see the information supplied under the listing for the Liberty Audiosuite measurement software.

Name: 4100 and 4000 series  
Distributor: Brüel & Kjaer

Price: Microphones US\$?  
Power supply/preamplifier US\$?  
Description: High quality precision instrumentation microphones.

Name: 7000 series  
Distributor: ACO Pacific Inc  
Price: US\$650 to US\$850 Microphones.  
US\$495 to US\$725 Preamplifiers.  
US\$450 to US\$575 Power supplies.  
US\$440 Sound level calibrator (94dB and 104dB).  
US\$1650 PS9200 Kit, includes PS9200 2-channel power supply, 4012 1/2" preamplifier with cable, 110VAC or 220VAC adaptor, 3" windscreens, fitted storage case, and your selection of a 1/2" measurement microphone. Other microphones and cases available (exchange credit given at list price).

Description: High quality precision instrumentation microphones for free-field and pressure response measurements. Typical frequency response for free-field microphones +/-2dB: Model 7022 1", 5Hz to 20kHz; Model 7012 1/2", 5Hz to 40kHz; Model 7046 1/2", 5Hz to 20kHz; Model 7016 1/4", 5Hz to 100kHz.

Name: ACO Pacific Model 3024 Noise Generator  
Distributor: ACO Pacific Inc  
Price: US\$695  
Description: Precision white and pink noise generator for use in acoustical and loudspeaker measurements, including 1kHz sinewave tone. White noise generator is pseudo random with 2.33 hour sequence, symmetrical Gaussian, 1.6Hz to 39kHz (-3dB). Pink noise generator has slope of -3dB/octave +/-0.25dB. Includes variable and step attenuators.

Name: Analog Devices ADXL05 accelerometer  
Distributor: Analog Devices Inc  
Price:  
Description: The ADXL05 single-chip, integrated, low-g accelerometer resolves minute changes in acceleration (from 0 to +/- 5g full-scale) with 0.005g resolution. The device combines a micromachined sensor, modulator, demodulator, voltage reference, signal conditioning, amplification, and on-command self-test circuitry on one polysilicon die. The ADXL05 was designed to simplify system complexity, improve performance, and reduce engineering costs in applications where tilt, inertial, shock, vibration, velocity, and acceleration characteristics must be measured.

Name: BK Precision LCR meters  
Distributor: Digi-Key Corporation  
BK Precision  
Price: BK-878-ND US\$275  
BK-875A-ND US\$200  
Carrying case US\$9  
Description: Both these meters are designed to measure capacitance,

resistance, and inductance. This includes the dissipation factor of capacitors and Q of inductors. 3-1/2 digit displays are provided. Accessories supplied: test clips, battery, spare fuse, instruction manual. Features of the BK-878 include: measurement accuracy of 0.7%, data hold function to freeze any displayed reading, a minimum/maximum/average function keeps track of the running average of readings and records the highest and lowest running values.

Name: C-550 and C550-A measurement microphones  
Distributor: Josephson Engineering  
Price: US\$400  
Description: The C-550 series of microphones are electret condenser capsules, 12.8mm in diameter, fitted in a machined-brass housing and requiring standard-DIN phantom powering from 14-52V DC. Each C-550 is supplied in a padded case, with an individual response calibration curve. Frequency response: 20Hz-20kHz, +/- 2dB. Maximum SPL: 130dB. Output: 3-pin balanced XLR. Output level: 10mV/Pa.

Name: MIC300 Test Mic  
Distributor: RCM Akustik  
Agent: Old Colony  
Price: US\$595  
Description: The MIC300 is a calibrated, omnidirectional condenser microphone developed specifically for sound ranging. Frequency response: 20Hz-20kHz. Maximum sound pressure for 0.5% distortion: 120dB. Phantom power: 10-48V. Calibration strip chart included. S/N ratio: 64dB. Mic is 190mm long.

Name: Mic Preamps Types 26AA, 26AB, 26AC  
Distributor: Scantek  
Price:  
Description: The G.R.A.S. Sound and Vibration microphone preamplifiers Types 26AA, 26AB, 26AC are suitable for use with 1", 1/2", 1/4" and 1/8" microphones, with or without polarization voltage, as well as for high-impedance input stages for instrumentation. They can also be used for accelerometers and hydrophones. Frequency range: 1Hz to 200kHz. Supply voltages: from below 28V to above 130V.

Name: Microphone Type M31, M51, and M52  
Distributor: LinearX Systems  
Price: M31 US\$160, M51 US\$280, M52 US\$400  
Description: The M31 is a low-voltage electret capacitor microphone for measurement of transducers, loudspeaker systems, room response, and other similar acoustic characteristics. It is small, has a wide and smooth frequency response, and its interface and power requirements are straightforward. It has a small 8mm diameter, producing less directional sensitivity for high-frequency measurements. The low voltage and current requirements of the microphone/preamp allow for easy setup and operation from a wide variety of power supplies, and it can also be powered from a 9V

battery. The M31 SPL capacity is 125dB, for the M51 13mm microphone it is over 150dB, and for the M52 13mm microphone it is over 170dB. Product information is also available from LinearX's Web site (see address details listed elsewhere).

Name: Mitey Mike  
Distributor: Old Colony Sound Lab  
Designer: Joseph D'Appolito  
Price: Unassembled Mitey Mike kit US\$149  
Assembled Mitey Mike with calibrated cartridge US\$219  
Description: Low-cost electret test measurement microphone based on a Panasonic condenser capsule. Provides flat free-field frequency response; high, undistorted SPL capability; excellent measurement repeatability; guaranteed long-term stability. Typical specifications (rel. 1kHz): +/- 1dB 20Hz-20kHz; +/- 2dB 10Hz-20kHz; -3dB @ 3Hz and 25kHz; sensitivity 39mV/Pa, +/- 2dB; max. undistorted SPL >120dBA; wideband noise level <42dBA; power consumption 5mW typical, 7mW max; power from 9V battery. This microphone has been approved as a third-party accessory to the DRA Laboratories' MLSSA analyzer.

Name: MMK-1 measurement microphone kit  
Distributor: Audio Precision, Inc  
Price: US\$2500  
Description: This kit includes a 12.7mm ACO microphone and preamp, connecting cable, a power supply, an ac-mains adapter, a cable to connect to the measurement equipment, and a windscreens. Microphone specifications: free field 0 degrees; 5Hz to 40kHz, +/- 2dB; dynamic range 22-160dB (3% THD). Preamplifier specifications: 28Vdc; 8Vpk into 10kohm load; 2Hz to 200kHz +/- 0.5dB. A sound pressure level calibrator MMC-1 is available for approximately US\$750.

Name: Neutrik 3382 measuring microphone  
Distributor: Neutrik  
Price: US\$210  
Description: An electret condenser capsule 7.5mm in diameter. The mic housing is made of stainless steel. Frequency response: 20Hz-10kHz, +/- 1dB; 10Hz-20kHz, +/- 2dB. Maximum SPL: 130dB (133dB with 30V DC supply).

Name: Nexus PHI-3 Phase Test System  
Distributor: Acoustic Control de Mexico  
Price:  
Description: The PHI-3 system is a tool that helps eliminate a basic problem with installation of sound equipment. You can test for absolute phase on amplifiers, equalizers, processors, speakers, drivers, or on complete sound systems. The PHI-3 system consists of a pulse generator unit and phase detector, and both units are necessary to check any sound system. The PHI-3 system has been designed to detect absolute phase, and will not be affected by changes of

phase at individual frequencies and their harmonics. It will detect a change of phase only if the polarity of the signal is inverted or if the mechanical movement of the transducer changes 180 degrees.

Name: Norsonic 1200 series

Distributor: Scantek Inc

Price:

Description: 1/2" measurement microphones and preamplifier.

Name: P500 Test System

Distributor: K & K International Aps

Price:

Description: The P500 is a test system for high-volume production quality control of speakers, microphones, telephone handsets, etc. Main test parameters include: frequency response; efficiency/sensitivity; polarity; loudness; rub and buzz; distortion; THD; impedance; resonance frequency and Q. The P500 can handle two production lines. Sweep time down to 0.5 seconds. Typical 3-4 seconds (20Hz-20kHz). Graphical presentation of test results and curve statistics. Password protected software.

Name: Panasonic electret condenser microphone cartridges

Distributor: Digi-Key Corporation

Price: US\$1.20 to US\$3.80, depending on model

Description: The Panasonic electret condenser microphone cartridges consist of a high voltage internal electret membrane, metal electrode and a FET. The cartridges are cylindrical, 6mm in diameter and 5mm in height. An external high-voltage bias is not required. Features include: highly efficient electrical specification, pressure type operating principle, low impedance (2.2kOhm), omnidirectional back directivity, and a high degree of reliability under adverse shock, vibration and environmental tests. Wide band response models, featuring a frequency range 20Hz-20kHz, are the WM-60AY (S/N ratio >38dB), WM-60AT (S/N ratio >58dB), and WM-063T (S/N ratio >38dB).

Name: PRE100 Mic Preamp

Distributor: RCM Akustik

Agent: Old Colony

Price: US\$295

Description: 212x101x35mm aluminium case, powered by 3x9V batteries.

Name: PVDF accelerometers

Distributor: PVDF Transducers

Price: US\$35

Description: PVDF is an alternative to piezoelectric material and allows a low-cost accelerometer to be produced, and has also found application in guitar pickups and microphones. The PVDF transducer consists of a 25mm by 100mm nylon and plastic encased strip of PVDF material affixed to a small plastic block. The block includes an output cable with connector.

The output needs to be connected to a preamp. The device is not calibrated, but is still useful for qualitative measurements of mechanical vibrations.

Name: Radio Shack Sound Level Meter (Cat. No. 33-2050)

Distributor: Radio Shack

Price:

Description: The Radio Shack sound level meter (SLM) is a handy device for basic measurements of sound pressure level. It includes a some fall-off in response at the extremes of the 20Hz-20kHz passband. An article titled "Converting Radio Shack's SLM to millivolt use" by C.L.P. Carrington (Speaker Builder 4/94, pp. 12, 13, & 56) describes some modifications to the meter to improve its bandwidth when used as a voltmeter.

Name: Shearcell ICP accelerometer, Model 352A22

Distributor: PCB Piezotronics Inc

Price: US\$495 for accelerometer

US\$155 for battery operated supply Model 480C02

Description: High-output, low-weight (0.5 grams) accelerometer. Possible applications include measuring cone excursion directly without significantly mass loading the cone. Attached to a panel of a speaker enclosure, the accelerometer could be used to measure the panel's vibration response, which may be useful in studying the effects of structural modifications or the application of damping materials to the enclosure walls. Frequency response: 5Hz-8kHz (+/- 3dB 1Hz-16kHz). Sensitivity: 10mv/g.

Name: Techfilter

Distributor: Onsite Instruments Inc

Price:

Description: The Techfilter is a PC board that provides anti-aliasing filtering suitable for use with various data acquisition boards. Features include: 16 channels of 75dB/octave lowpass filters; cutoff variable from 1Hz to 25kHz; 16 single-ended or differential input channels; gains of 1, 10, 100, 1000; ac or dc coupling; all functions controlled by software.

Name: Thurlby Thandar TC200A hand-held LCR meter

Distributor: Electronics World & Wireless World

Price: 100 Pounds Sterling (UK only)

104 Pounds Sterling (Europe)

109 Pounds Sterling (Rest of the world excluding USA)

30 Pounds Sterling Surface Mount Component Probe

Description: The TC200A is a precision hand-held LCR meter featuring nine capacitance ranges, eight resistance ranges, and seven inductance ranges. The TC200A is also capable of displaying dissipation factors in the range 0 to 1.999 for both capacitance and inductance. Measuring 177x88x40mm, the pocket sized TC200A weighs just 400 grams. It has a 3.5 digit high- contrast display with 12.7mm high characters,

and runs from a single standard 9V battery. The meter is designed to provide a fast measurement response time. A probe specially designed for measuring surface mount components is available. The following capacitance ranges are available (range/resolution/accuracy): 200pF/0.1pF/1%; 2nF/1pF/1%; 20nF/10pF/1%; 200nF/100pF/1%; 2uF/1nF/1%; 20uF/10nF/1%; 200uF/100nF/1%; 2mF/1uF/2%; 20mF/10uF/2%. The following inductance ranges are available (range/resolution/accuracy): 200uH/0.1uF/2%; 2mH/1uH/1%; 20mH/10uH/1%; 200mH/100uH/1%; 2H/1mH/2%; 20H/10mH/2%; 200H/100mH/3%. The following resistance ranges are available (range/resolution/accuracy): 2ohm/1mohm/1%; 20ohm/10mohm/1%; 200ohm/100mohm/1%; 2kohm/1ohm/1%; 20kohm/10ohm/1%; 200kohm/100ohm/1%; 2Mohm/1kohm/2%; 20Mohm/10kohm/2%.

#### ACOUSTIC MODELLING AND AURALIZATION

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Name: AcoustaCADD  
Computer: MS-DOS  
Distributor: Altec-Lansing/ElectroVoice  
Programmer: Akira Mochimaru  
Price: US\$1000  
Description: Features include: statistical ray tracing; SPL distribution mapping; estimated reverberation time; allows input of room data.

Name: CADP2  
Computer: MS-DOS  
Distributor: JBL  
Programmer: Gary Hardesty  
Price: US\$1800  
Description:

Name: CATT-Acoustic 6.0  
Computer: Microsoft Windows 3.1  
Distributor: CATT  
Agents: Munro Associates  
Programmer: Bengt-Inge Dalenback  
Price: 20000 SEK (approx. US\$2500) for the prediction part.  
20000 SEK (approx. US\$2500) for the binaural post-processing/  
auralization part.

Description: The CATT-Acoustic software is designed for room acoustic prediction and desktop auralization. It uses an image source model and ray tracing with the ability to vary wall subdivision, wall absorption, and source data (directivity, aim, power spectrum). Ray tracing is used for audience area early SPL and ray direction coverage mapping in four user selectable arrival-time intervals (eg. 0-20, 20-50, 50-80, and 80-200 ms). Walls, or parts of walls, can be assigned both an absorption factor, a "diffusion factor", and an automatic size-dependent diffusing edge-effect. Due to the

frequency dependence of diffuse reflection, separate ray-tracing is performed for each octave. Source directivity is approximated from horizontal and vertical polar measurements. The octave band range is 125Hz to 4kHz plus power-sum over 125Hz-4kHz. Data input is accomplished by free format ASCII hierarchical geometry files with comments. Symbolic constants, arithmetic expressions and math functions can be used to specify coordinates. User extensible data libraries are available for source directivity and absorbing/diffusing properties. Room acoustic measures include: reverberation time, SPL, RASTI, definition, clarity, lateral energy fraction, centre-time, direct to reverberant ratio, mean absorption factor, and mean free path. Graphs include: interactive 3D geometry projection (natural, parallel, and camera with variable lens); x-y, x-z, y-z views; interactive reflection tracing; reverberation decays; impulse response (dB-scale backward/forward integrated, linear, "ear-integrated" with Sone scale); absorption statistics; interactive wall hit statistics; image source space; room acoustic measures; RASTI; early part SPL and ray direction mapping; source directivity polar and 3D balloons. Presentation of results is accomplished by viewing plot files one at a time, in sequence interactive, or in sequence automatic (for presentations and demonstrations) and with optionally added text. All plot files can be "zoomed" to reveal details. Hardware requirements: the programs run in protected mode on IBM compatibles (80386/87 and above), and use virtual memory techniques; SuperVGA, VGA, EGA or Hercules graphics; plots to HPGL plotters or PostScript printers. Desktop auralization is available: binaural auralization with measured HRTFs and analytical HRTFs (sphere); stereo auralization (Blumlein pair); mono auralization (directive microphones); use MATLAB FIRs; use measured MLSSA FIRs; convolution with anechoic music/speech without the need for specialized hardware (10 s of music is convolved with 1.5 s long binaural FIR in 5 min using a 486DX2); anechoic and processed material utilizes Microsoft Windows WAVE format (to play use 16-bit stereo Windows-compatible soundcard); 16, 22.05, 32, 44.1 and 48 kHz operation; optionally a Lake FDP-1+ convolution processor can be used for real-time convolution (see address list for contact details for Lake DSP). A Microsoft Windows interactive demo of CATT-Acoustic V6.0 is available by directly contacting CATT.

Name: Convoltotron

Computer:

Distributor: Crystal River Engineering

Programmer: Scott Foster

Price:

Description:

Name: EASE (Electro-Acoustic Simulator for Engineers)

Computer: MS-DOS

Distributor: Renkus-Heinz Inc.  
Programmer: Rainer Feistel and Wolfgang Ahnert  
Price: US\$1995  
Description: Simulates the performance of sound reinforcement systems in an acoustic environment. It simulates, analyzes, and predicts the performance of a system in a specific room. Includes an open format data base containing loudspeaker data with acoustical performance and physical data, which can be viewed as polars, isobars, or in a 3-D directivity display. Displays coverage isobars, with a 3-D energy grid to show multiple source interference effects. Calculates and displays reflections, shadowing effects, multiple source comb filtering, and relative arrival times. Data entry for room modelling using X,Y,Z coordinates taken directly from architectural drawings or by importing room drawing files from AutoCAD.

Name: Modeler Design Program  
Computer: Apple Macintosh  
Distributor: Bose Corporation  
Programmer: Tom Birkle  
Price: US\$700 (?)  
Description: Performs geometric, acoustic, electroacoustic and psychoacoustic simulation of sound systems in arbitrary spaces (small rooms to open-air theatres). Features include: input of geometric boundaries; handles obstructing surfaces such as balconies; surface boundaries include octave-band Sabine absorption coefficients; driver data uses directivity balloons; numeric and gray-scale maps of SPL; models arrival times at user specified locations; reverberation time modelling; clusters can be aimed.

#### OTHER AUDIO DESIGN PROGRAMS

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Name: AModel Program  
Computer: MS-DOS  
Distributor: Pat Brown  
Programmer: Joe Mitchell  
Price: US\$25  
Description: AModel is a simple program for mathematically modelling the polar frequency response of arrays of loudspeakers. It is written in the C language. AModel calculates the frequency response in 360 1-degree steps around the model at a distance of 30ft from the origin in the horizontal XZ plane, of up to 50 point sources (or microphones) with a simulated Q applied for each source. Modelling in the vertical plane is performed by rotating the model -90 degrees about the Z axis (e.g. take a vertical column speaker and lay it down on its side). AModel uses a left-handed coordinate system with elevation angles as an X axis rotation and windage as a Y axis rotation relative to the -Z axis which is the "on axis" reference. GraphA is a

simple companion program that plots the data in polar form via color coded 3dB intensity contours, referenced to the greatest intensity that occurred in the entire model.

Name: Analysis Advisor  
Computer: Microsoft Windows 3.1  
Distributor: National Instruments  
Price: Free  
Description: Analysis Advisor is a free interactive analysis software tutorial that includes demonstrations of graphical and traditional programming methodologies for analysis. Using this interactive tutorial you can investigate: digital signal processing, digital filtering, windowing, curve fitting, signal averaging, simulation, interpolation, descriptive statistics, speed benchmarks.

Name: BestPlace  
Computer: Microsoft Windows 3.1, Apple Macintosh  
Distributor: RA Labs  
Price: Free  
Description: BestPlace is a speaker placement program that plots a room augmentation curve for a speaker placed at any position within the listening room. The program can be found on the Web at <http://members.aol.com/ralabsusa/bstplace.htm>.

Name: Listening Room  
Computer: MS-DOS and Apple Macintosh  
Distributor: Sitting Duck Software and Old Colony Sound Lab  
Price: US\$48 (MS-DOS), US\$68 (Apple Macintosh)  
Description: Predicts standing waves modes in small rooms and is designed for positioning speakers - and the listener - in such a way as to minimize standing wave effects and other room-generated influences. The program allows for a full range of speaker and listener movement in 3D space and continuously updates a standing wave pressure versus frequency display.

Name: MathCAD utilities  
Computer: Microsoft Windows 3.1 with MathCAD for Windows  
Distributor: Pat Brown  
Programmer: Pat Brown  
Price: US\$25  
Description:

Name: PHD Program 4.0  
Computer: MS-DOS  
Distributor: Richard C. Heyser Scholarship Loan Fund  
Programmer: John Prohs  
Price: Free gift with donation of US\$300 or more.  
Description: Models the performance of loudspeaker array systems. Features include: acoustical coverage, power and performance analysis; calculates Q and energy distribution; effect of "direct sound" absorption on sound field; view design simulation in all directions; acoustical gain

examinable at any location; Peutz and RASTI intelligibility prediction; English or metric units; Sabin and Fitzroy calculations; outdoor or indoor with air absorption factors; true statistical and semi-reverberant field; single or multiple loudspeaker clusters; isobar patterns for multiple frequencies.

Name: Sound System Design spreadsheet  
Distributor: Pat Brown  
Programmer: Farrel Becker  
Price: US\$25  
Description: Requires Lotus 123 spreadsheet or equivalent.

Name: DIODORE - Underwater Acoustics  
Computer:  
Distributor: Principia Recherche Developpement  
Address: Place Sophie Laffitte, Valbonne BP22-06560, France  
Programmer: Mr Butery  
Price:  
Tel: +33 93-74-81-00  
Description:

Name: Electro Acoustic Estimating  
Computer:  
Distributor:  
Programmer: Mario Maltese  
Price:  
Description:

Name: IEEE Digital Signal Processing Software  
Computer:  
Distributor: IEEE Acoustics, Speech and Signal Processing Society  
Price:  
Description:

Name: NASTRAN (Does anyone really use this for room acoustics?)  
Computer: MS-DOS and various Unix workstations  
Distributor: McNeal/Schwendler  
Price:  
Description:

ANYTHING IN DEVELOPMENT  
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Name:  
Distributor: YAMAHA  
Address:  
Programmer:  
Tel:  
Fax:  
Price:

Name:  
Distributor:  
Address: Cornell  
Programmer: Adam Stetner  
Tel:  
Fax:  
Price:

Name:  
Distributor:  
Address: Bell Labs  
Programmer: Gary Elco  
Tel:  
Fax:  
Price:

Name:  
Distributor:  
Address: Ford Motor Company  
Programmer: Earl Getty (should this be Earl Geddes?)  
Tel:  
Fax:  
Price:

Name:  
Distributor:  
Address: Canon Supercomputing, Kanagawa, Japan  
Programmer:  
Tel:  
Fax:  
Price:

Name:  
Distributor:  
Address:  
Programmer: Prof Blauert (Bochum University, Germany)  
Tel:  
Fax:  
Price:

Name: Oedon  
Distributor: Danish Acoustical Institute of Copenhagen  
Address:  
Programmer: Nils Bundgaard, nillsb@daimi.aau.dk (Tel: +45 8619-5722)  
Tel:  
Fax:  
Price:

Name: Epidaure  
Distributor: Centre Scientifique et Technique du Batiment  
Address: Grenoble, France  
Programmer:  
Tel:  
Fax:

Price:

Name:

Distributor:

Address: University of Sherbrooke, Quebec, Canada

Programmer: J Nicolas, F Laville (819) 821-8563

Tel:

Fax:

Price:

Name:

Distributor:

Address:

Programmer: Takenaka Corp Lab. (Japan)

Tel:

Fax:

Price:

Name:

Distributor:

Address:

Programmer: Kajima Corp Lab (Japan)

Tel:

Fax:

Price:

Name: Images

Distributor:

Address:

Programmer: Sam Berkow

Tel:

Fax:

Price:

Name: Cobasesteel

Distributor:

Address:

Programmer:

Tel:

Fax:

Price:

Name: Acoustaboom

Distributor:

Address:

Programmer: Toyota

Tel:

Fax:

Price:

Name: Bmap

Distributor:

Address:

Programmer: US Navy

Tel:  
Fax:  
Price:

Name: Sysnoise  
Distributor:  
Address:  
Programmer: US Navy  
Tel:  
Fax:  
Price:

#### ACTIVE CROSSOVERS AND EQUALIZERS

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Active crossover networks offer some performance advantages compared with passive crossovers, and as a result they have always been popular in pro audio applications. Also, equalizers can be helpful in correcting certain types of response problems that might be present in a loudspeaker system.

Model: Ashly XR Series Crossovers  
Distributor: Ashly Audio Inc  
Description: Active crossovers with 24 dB/octave slope using 4th-order state-variable filters. Variable filter response for Linkwitz-Riley and other filter characteristics. Accurate, wide-range continuous tuning for flexibility of application. These crossovers feature low noise and distortion, active balanced inputs, a peak level indicator, a precision regulated power supply, protection against abnormal input or output conditions, and rugged mechanical construction. These crossovers can be easily reconfigured for nonstandard operation. For example, a 4-way crossover can easily be used as a mono 2-way with tunable infrasonic and ultrasonic cutoff filters, and a stereo 3-way can function as a mono 5-way crossover; no internal modifications are necessary.

Model: C-101 Series III Analyzer/Equalizer  
Distributor: AudioControl Electronic Engineering & Manufacturing Inc  
Description: 10-band graphic equalizer with +/- 15dB equalization and real time spectrum analyzer and calibrated microphone that allows accurate analysis of listening rooms using built-in digital pink noise generator; high-speed low-noise opamps; digital audio switching to provide shorter signal paths for better noise rejection; sharp 18dB/octave infrasonic filter to remove power wasting infrasonic frequencies that may damage speakers; fully regulated power supplies to maintain constant power levels for consistent performance and lower distortion.

Model: Octave Equalizer  
Distributor: AudioControl Electronic Engineering & Manufacturing Inc

Description: 10 band equalizer with 3rd-order infrasonic filter.

Model: Ten Equalizer

Distributor: AudioControl Electronic Engineering & Manufacturing Inc

Description: 10 band +/- 15dB equalizer with independent L/R channel equalization and 3rd-order infrasonic filter.

Model: Ten Plus Analyzer/Equalizer

Distributor: AudioControl Electronic Engineering & Manufacturing Inc

Description: 10 band +/- 15dB equalizer with independent L/R channel equalization, including warble tone generator, measurement microphone and illuminated SPL meter. Useful for equalization of home theatre systems.

Model: Richter Scale Series III Analyzer/Equalizer

Distributor: AudioControl Electronic Engineering & Manufacturing Inc

Description: 6 band 1/2-octave bass +/- 12dB equalizer, including 24dB/octave Linkwitz-Riley electronic crossover, warble tone test source, SPL meter and calibrated microphone.

Model: 2XS, 3XS, 4XS in-car electronic crossovers

Distributor: AudioControl Electronic Engineering & Manufacturing Inc

Description: The 2XS is a 2-way, 2-channel, 18dB/octave electronic crossover. The 3XS is a 2-way, 4-channel, 24dB/octave electronic crossover. The 4XS is a 3-way/2-channel or 2-way/2-channel electronic crossover. The 24XS is a 2-way 2-channel 24dB/octave Linkwitz-Riley electronic crossover with facility to change phase continuously from 0-180 degrees on either the highpass or lowpass sections. All crossovers feature programmable crossover frequencies.

Model: XM1, XM6, XM9, and XM16 electronic crossovers

Distributor: Marchand Electronics Inc

Description: All models are based on state variable Linkwitz-Riley filter topologies and are of low-noise and low-distortion design using high grade components. The XM1 features: 24dB/octave filters; crossover frequency selection is made by changing the value of four resistors; crossover frequency 20 to 5000Hz. The XM6 features: 24dB/octave filters; digital crossover frequency readout; crossover frequency can be changed from the front panel over a total of 163 frequencies (steps range from 1Hz at 20Hz to 100Hz at 5000Hz); an optional RS232 or MIDI interface enables computer control of crossover frequency; subwoofer summing option. The XM9 features: 24dB/octave filters; level controls on circuit board (optional off-board); subwoofer summing option; gold plated RCA connectors; crossover frequencies adjustable by purchasing a low-cost frequency module, with available stock crossover frequencies of 20, 30, 40, 50, 60, 70, 80, 90, 100, 125, 200, 250, 500, 1000, 2000, and 5000Hz (other frequencies available on request). The XM16 features: 48dB/octave filters; level controls on the board (optional off board controls); subwoofer summing option; no turn on/off transients; crossover frequency

20-5000Hz; crossover frequency selection by changing the values of two sets of eight resistors. Most products are available as a kit or fully assembled. 120/240 VAC 50/60Hz operation is usually possible. Some variants are for in-car use. The WM8 Bass Correction Equalizer is an equalizer that can extend the bass response of acoustic-suspension speakers. The damping (Q) of the new bass cutoff can be adjusted according to the listening room acoustics and the user's tastes. A variety of power amplifier and power supply modules are also available.

Model: PM26 vacuum tube crossover  
Distributor: Marchand Electronics Inc  
Description: A vacuum tube crossover, using 12AX7 tubes is said to be due for release in the future.

Model: AC-22 and AC-23 electronic crossovers  
Distributor: RANE Corporation  
Description: The AC-22 and AC-23 are stereo two-way and three-way 4th-order Linkwitz-Riley state variable time correcting active crossover units with automatic internal switching. Precision 41-detent continuous frequency selectors are provided. To maintain all the low lobing error advantages of Linkwitz-Riley filter performance, both models include continuously variable 0-2ms time delay sections to provide electronic phase-alignment of each pair of drivers at the crossover points. Extensive manuals are provided which include step-by-step procedures. Both models feature 18dB/octave infrasonic filters from 20Hz, and ultrasonic filters from 20kHz. 120/240 VAC 50/60Hz operation is possible. Individual band muting switches are provided for ease of tuning. Balanced/unbalanced inputs are available. A range of graphic and parametric equalizers is also available.

Model: 24CX-2/3/4 electronic crossovers  
Distributor: TDM Design  
Description: Utilize 24dB/octave crossover slopes for greater driver protection. A 4th-order state variable Linkwitz-Riley filter design is used, and provides a flat summed electrical response throughout the crossover region. The circuitry uses precision 2% metal oxide film resistors, selected capacitors, precision matched 1% four-gang frequency range potentiometer, and high slew-rate low-noise operational amplifiers to guarantee excellent sound quality and overall electrical performance. There is provision for optional low summing, and the units have balanced or unbalanced inputs and outputs. Other features include: built-in constant directivity horn equalization; integral security cover; optional adjustable limiters on all outputs; insertion connector on each output for option cards; each filter section can be used independently or combined with any of the other sections. 120/240 VAC 50/60Hz operation is possible.

Model: ACT-1 electronic crossover  
Distributor: Welborne Labs  
Description: The ACT-1 is an active crossover kit which features: totally modular design; Class-A discrete circuitry; balanced and unbalance input/output; 2-way and 3-way system capability; 1st, 2nd, 3rd, and 4th order networks. The kit is based on a Jean-Claude Gaertner/Erno Borbely design.

Distributor: Sussex Technical Corp.  
Description: Products included steep slope electronic crossovers and a bass equalizer to extend low-frequency response by 2/3 octave.

#### USEFUL REFERENCES ON LOUDSPEAKER SYSTEM DESIGN

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Of all the technical publications on loudspeaker system design that are presented here, the first six are particularly useful since they contain a wealth of collected information. Also, many of the journal articles published by the Audio Engineering Society that are referenced in this bibliography are contained within the AES publications listed at [1] and [2].

Please note that this list is definitely far from exhaustive; there have been many more contributions to the field of loudspeaker design than it is possible to include here.

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K & K International ApS  
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Liberty Instruments, Inc  
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Fax: 408-434-0507

LinearX Systems, Inc  
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Fax: 503-598-9258  
BBS: 503-598-9326  
Ftp: ftp.teleport.com in /pub/vendors/linearx  
Web: http://www.linearx.com/~linearx/  
Email: info@linearx.com

Madisound Speaker Components  
PO Box 44283, 8608 University Green, Madison, WI 53744-4283, USA  
Tel: 608-831-3433  
Fax: 608-831-3771  
Email: madisound@itisp.com  
Web: http://www.itisp.com/madisound/  
BBS: 608-836-9473 (Audio Projects BBS, US Robotics HST modem answering at  
9600/2400/1200/300 baud, MNP Class 5 also,  
8 bit, no parity, 1 stop bit)

Mahogany Sound  
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Marchand Electronics Inc  
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MicroSim Corporation  
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Fax: 714-455-0554

MTX  
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National Academy of Mobile Electronics  
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National Instruments  
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PVDF Transducer  
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RA Labs USA  
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Rockford Corporation  
613 S. Rockford Drive, Tempe, AZ 85281, USA  
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Snell Acoustics  
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If you have any additions or revisions for this document, comments on any products listed here, suggestions, recommendations, or information to fill in the various blanks, please email them to:

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